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MEASURING PRODUCTIVE EFFICIENCY IN AIR FORCE OPERATIONAL CONTRACTING SQUADRONS: AN APPLICATION OF DATA ENVELOPMENT ANALYSIS

THESIS

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The views expressed in this thesis are those of the authors and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

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Abstract

In an effort to improve the management feedback in operational contracting squadrons, this research concentrated on the development of an alternate method to measure operational contracting performance. Specifically, the research investigated the use of Data Envelopment Analysis (DEA) to measure the productive efficiency of 45 operational contracting squadrons. Operational contracting managers were surveyed to identify critical resources to and outputs from the contracting process. Based on this survey, four inputs and five outputs were included in the DEA model. The DEA was executed for each contracting squadron under study. The DEA output provided improved performance measurement and feedback information. DEA combined multiple inputs and outputs into a single measure of performance. Because it allows flexible weighting of decision variables, DEA accounted for differences in squadron size, mission, and purchase complexity. By examining the DEA generated Hypothetical Comparison Unit, specific input reductions and output increases were established for each relatively inefficient squadron. Finally, the DEA output addressed several desired characteristics of a performance measurement system identified by contracting managers.

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I. Introduction

Whether called contracting, acquisition, or purchasing, the function of acquiring goods and services has evolved into a critical aspect of both commercial industry and government operations. In recent years, the commercial sector has recognized purchasing as an activity which contributes directly to company profits (41:27). With inevitable decreases in the military budget, the Department of Defense (DOD) has realized the importance of improving efficiency and productivity in contracting operations. Before improvements can be achieved, contracting managers must measure and obtain feedback on performance.

The Air Force conducts purchasing activities in a number of locations. At each Air Force base, purchasing activities are conducted by the operational contracting squadron. This squadron is responsible for acquiring all goods and services to maintain and operate the base. Base acquisition may include simple items such as office supplies and fuel or more complex items such as construction or physician support services. The magnitude of base acquisition is quite large. The Contracting Activity Report

(RCS HAF-RDC M&A 7106), revealed Air Combat Command's (ACC) 38 squadrons executed 1,085,009 contracting actions valued at $1,615,490,047 during fiscal year 1992. ACC is just one of several major commands in the Air Force.

General Issue

The ability to measure and provide feedback concerning productivity or efficiency is important to operational contracting for several reasons. First, efficiency and productivity are major factors of an operational contracting squadron's performance. Traditional definitions of purchasing performance include the concepts of effectiveness and efficiency. Effectiveness is difficult to measure in a service function because it includes subjective ratings of goal attainment and customer satisfaction (56:17).

Purchasing efficiency and productivity are closely related concepts which can be measured with greater accuracy. Purchasing efficiency is the relationship between "planned and actual sacrifices made in order to realize a goal previously agreed upon" (56:19). Productivity is a measure of the ratio of outputs produced by an organization compared to the inputs used to create the output (42:420). As major components of overall purchasing performance, the ability to measure efficiency and productivity is an important tool for operational contracting performance improvement.

Another reason to measure and provide feedback concerning operational contracting performance is its importance to maintaining national defense. The operational contracting squadron provides each Air Force base with the supplies and services to maintain its defense posture. Given the current era of increasing government deficits and declining defense budgets, the need to measure and improve purchasing efficiency, thus reducing operational costs, is vital to maintaining national defense (28:46). Just as industry is discovering, purchasing plays a major role in achieving Air Force mission objectives.

A final reason to measure and provide feedback concerning operational contracting performance is the current implementation of the Defense Business Operations Fund (DBOF). In an attempt to adapt to lower budgets and personnel levels, the DOD formally established DBOF in fiscal year 1992 (28:45). The long range goal of DBOF is to move all mission support activities into a large revolving fund account (53:11).

Although not fully implemented, DBOF attempts to model DOD support operations along the lines of the private sector. Mission support activities, like operational contracting, will no longer receive direct appropriated funding. Instead, commanders of direct mission elements will receive funds which may be used to purchase support activities (28:47). These commanders will then choose a support service based on the lowest cost available. In effect, DBOF will force competition for work among those organizations providing services within the Air Force.

The price charged for support services under DBOF will be determined through unit cost accounting measures. Costs are currently being developed based on total costs per unit of output (53:11). Once developed, these costs will establish the price mission commanders must pay for service functions. Under DBOF, improvements in contracting squadron productivity and efficiency will lower the unit cost of service. The most efficient squadrons may garner the majority of funding or compete with the threat of privatization of the operational contracting mission.

Current Methods Of Measuring Operational Contracting Performance. Under current practices the Air Force has limited methods of measuring how well the operational contracting squadron creates outputs from a given level of resources or inputs. In other words, the Air Force has no way to measure and provide feedback concerning productive efficiency. The current method of overall performance measurement involves four separate systems. These systems are described briefly in the following paragraphs, with detailed explanations and system weaknesses provided in Chapter II.

The first system of performance evaluation is the self-inspection. A self-inspection integrates compliance based issues into a checklist. This checklist is used by members of the operational contracting squadron to evaluate overall performance. Because it is a compliance based review, the self-inspection provides limited feedback on productivity and efficiency. The main concern of a self-inspection is to ensure proper adherence to laws and regulations, and proper contract documentation.

The second system is the use of the Command Inspector General (IG) to conduct a compliance evaluation of each squadron. These evaluations are made every twelve to eighteen months and last between seven and ten days. Like the self-inspection, the IG is a compliance based inspection. Because of the extended time between IG visits, the system provides infrequent feedback to contracting managers.

The third system of operational contracting performance evaluation is the attainment of Command and Air Force goals. These goals normally concentrate on competitive purchasing and socio-economic policy. For example, each squadron is judged against a pre-established small business usage standard. These goals are set at the beginning of each fiscal year. Once again, the feedback provided is infrequent and provides little information on productivity or efficiency.

The final system of performance measurement is the contracting manager's ability to extract and compare individual measures from the Base Contracting Automated System (BCAS). These measures provide individual metrics for various facets of performance. For example, the BCAS system provides measures on total dollars awarded, contract administrative lead time (CALT), and the number of purchases made competitively. Currently, there is no method to aggregate these individual measures into an overall index of performance. In addition, the BCAS measures provide no indication of performance relative to other contracting squadrons.

Data Envelopment Analysis: A Recent Development in Productivity Measurement. A possible addition to current methods of operational contracting performance measurement is the technique of Data Envelopment Analysis (DEA). DEA is a mathematical programming technique developed by Charnes, Cooper, and Rhodes in 1978 (13:429). The technique is described in detail in Chapter III, however a brief description of DEA and its advantages are outlined in the following paragraphs.

An advantage of DEA is its ability to establish a composite index of overall performance based upon relative productive efficiency, or productivity, of each operational contracting squadron. The method uses traditional simplex linear programming to provide an overall ranking of performance for each member of a set of comparable producing units. These units are termed Decision Making Units (DMUs) in the DEA methodology. The use of DEA is appropriate when it is difficult to place an economic price or value on a DMU's resources or outputs (49:7).

Another advantage of the DEA methodology is its ability to account for differences between each contracting squadron. By allowing flexible weighting of inputs and outputs, the technique ensures differences in squadron missions, goals, responsibilities, and purchase complexity are considered when performance is evaluated. The ability to account for squadron differences is a characteristic absent from current methods of evaluating operational contracting performance.

The DEA technique can convert multiple input and output measures into a single index of productive efficiency (22:90). Inputs are the resources used to produce a product or service. Examples of operational contracting inputs are the number of buyers, contract administrators, and experience level of the work force. Operational contracting outputs may include the total contracting actions, total line items awarded, or total dollars obligated.

A final major advantage of the DEA technique is its ability to provide meaningful feedback to contracting managers. Each operational contracting squadron can be evaluated relative to the best performing squadrons across the Air Force. Once evaluated, the DEA technique provides managers with information about reductions in inputs or increases in outputs required to improve performance.

Specific Problem Statement

Headquarters United States Air Force (SAF/AQCO) and the Air Force Logistics Management Agency (AFLMA/LGC) identified a need to develop and evaluate an alternative method of measuring operational contracting performance (27). The alternate method must satisfy evaluation and feedback needs identified by operational contracting managers. Because of its favorable characteristics and ability to measure performance in the service and non-market sectors of an economy, the DEA technique was chosen as a possible alternative to current methods of performance evaluation.

Research Objectives and Related Investigative Questions

The overall objective of this research was to design a DEA evaluation system that provides an alternative to current methods of measuring operational contracting performance. As an alternative method, the DEA model should be compared to the needs identified by management. In order to address the specific problem, the research was broken down into two main objectives. Each objective contains related investigative questions (IQ).

Objective 1. Develop a DEA model for operational contracting.

IQ 1: What are the most critical outputs generated from the operational contracting function?

IQ 2: What are the most critical resources available to operational contracting squadrons?

IQ 3: What are the results of the application of the DEA technique to operational contracting performance measurement?

Objective 2. Evaluate DEA's output and potential use to managers for performance evaluation.

IQ 4: What information does the DEA output provide the Air Force operational contracting manager?

IQ 5: What characteristics of a performance measurement system are desired by operational contracting managers and how are they addressed by DEA?

Scope and Limitation of the Research

The development of a DEA model for operational contracting squadrons required the use of a multi-step process. The first step was to identify potential resources and outputs of operational contracting. Once identified, a survey was developed so that operational contracting managers could identify the most important input and output measures. This survey also queried operational contracting managers about desired characteristics of a performance measurement and evaluation system. After identification of the critical variables, the DEA model was constructed.

The DEA model was constructed using archival data from the BCAS system. The data included measures for all management identified input and output variables from fiscal year 1992. Once the model was constructed, it was executed using standard simplex linear programming software. DEA results were then compared to the desired evaluation system characteristics identified through the survey of operational contracting managers.

The survey to identify critical contracting inputs and outputs was administered to management at all Continental United States (CONUS) operational contracting squadrons. Management was limited to Base Contracting Officers (BCOs), Deputy BCOs, and Executive Officers/Non-Commissioned Officers (NCOs). These positions represent the top three military and/or civilian managers at each squadron. Because a research goal was to construct a model based upon management input, no attempt was made to survey non-management personnel concerning critical inputs and outputs.

Once inputs and outputs were identified by CONUS contracting management, archival data were collected from 45 operational contracting squadrons within Air Force Material Command (AFMC) and Air Combat Command (ACC). These commands were selected because their archival input and output data were readily available for use in this investigation of DEA applicability. The input and output data from these 45 bases were used for DEA model development. The DEA results reported in Chapter IV are limited to a comparison of performance for the 45 AFMC and ACC bases.

Operational Definitions

The majority of operational definitions used in the research are included in the body of the thesis. This approach allows the reader immediate reference to a specific definition as it is initially presented. However, the following terms are used extensively and require initial operational definition.

Inputs - The resources available to an organization which are used in the generation of outputs. In the operational contracting squadrons, examples of inputs include the number of buyers, contract administrators, and the average experience level of the personnel.

Outputs - The products or services produced by an organization. In the operational contracting squadron, examples of outputs include the contract administrative lead time (time elapsed from receipt of purchase request until contract award), the total number of contracts awarded, and the total dollars obligated.

Performance - Overall manner in which an organization (the operational contracting squadron) fulfills its intended purpose as measured against some standard.

Productivity - The relationship between the output of an organization and the inputs that have gone into producing the output. Often depicted as measures such as output per man-hour.

Efficiency - A concept closely related to productivity. Most often concerned with the relationship between scarce resources and the outputs of an organization. Efficiency is used as a criterion for judging how well an organization has allocated its available resources to produce outputs.

Productive Efficiency - Because the concepts of productivity and efficiency are closely related, performance measurement literature often use the terms together. For purposes of this research, all three terms refer to the process of using inputs to create outputs in the operational contracting squadron.

Decision Making Unit (DMU) - In the DEA methodology, a DMU is the organizational element which is analyzed relative to similar elements. For the purpose of this research, a DMU is an operational contracting squadron.

Relative Efficiency - The efficiency of a DMU when compared to all other DMUs.

Absolute Efficiency - The efficiency of an organization when compared to some hypothetical standard of efficiency.

CALT - Contract Administrative Lead Time. CALT is the time elapsed from the moment a purchase request is received in the contracting squadron to the time the purchase is made.

ACC - Air Combat Command.

AFMC - Air Force Material Command.

BCAS - Base Contracting Automated System. The management information and reporting system currently used by operational contracting squadrons.

7106 Report - BCAS Contracting Activity Report (RCS HAF-RDC M&A 7106). This report provides a majority of the management information to contracting squadrons.

Structure of Thesis

Chapter II reviews the applicable literature concerning performance measurement in operational contracting squadrons. The chapter is designed to demonstrate the importance of an alternate method for measuring operational contracting performance. The reader is introduced to the general functions of the operational contracting squadron, the importance of performance measurement in these squadrons, and current techniques used for performance measurement. The chapter concludes with a introduction to the DEA methodology and examples of application in public and service providing sectors of the economy.

Chapter III explains the multi-step methodology used to gather and use available data. The first part of Chapter III provides a detailed explanation of the DEA methodology. This explanation includes a graphical solution of a simple two input, single output operational contracting example. The DEA linear program is also developed in part one of Chapter III.

After the complete description of the DEA methodology, part two of Chapter III outlines the specific techniques used to answer each of the five investigative questions. These methods include a discussion of the survey used to identify input and outputs, methods of identifying characteristics of a performance evaluation system, and methods to compare DEA to the desired characteristics.

An analysis of the input and output identification survey is made in the initial portions of chapter IV. The majority of the chapter is devoted to the analysis of the DEA output from the operational contracting application. This analysis concentrates on the information provided to the operational contracting manager by DEA output. In addition, a comparison of DEA characteristics with desired characteristics of a performance evaluation system is made.

Chapter V summarizes the research and draws conclusions about the DEA application based upon the analysis conducted in the previous chapter. These conclusions concentrate on the significance of the findings and practical implications of the results. Finally, recommendations for future research on the topic are made.

II. Literature Review

Overview

The purpose of this chapter is to provide a review of the applicable literature concerning performance measurement in operational contracting squadrons. The chapter is divided into seven specific areas designed to demonstrate the importance of an alternate method for measuring operational contracting performance.

First, the general functions of operational contracting are described in greater detail. The second section covers the importance of measuring the performance of an operational contracting squadron. This includes reasons that are both specific to the DOD and applicable to all purchasing activities. A working definition for purchasing performance is reviewed in the chapter's third section. The fourth part of the chapter concentrates on a review of the four methods currently used to evaluate operational contracting squadrons. Specific weaknesses of these methods are highlighted. The fifth section discusses techniques that are often used to measure purchasing performance outside the DOD. Once again, technique weaknesses are highlighted. The sixth section provides general difficulties in measuring performance in public agencies. This section concentrates on a lack of quantifiable measures and the inability to estimate a production function.

The final part of the chapter introduces an alternate method of measuring performance for possible use in the operational contracting environment. This alternate method is defined as Data Envelopment Analysis (DEA). The DEA literature is reviewed in order to establish its ability to address shortcomings of other available performance measurement techniques. Previous applications of the DEA technique demonstrate its possible use in the measurement of operational contracting squadron performance.

The Function of Operational Contracting Squadrons

The operational contracting squadron is the organization responsible for purchasing the majority of supplies and services for each Air Force Base. These purchases are made in direct support of Air Force mission requirements. The purchasing function may be as simple as office supplies procurement or as complex as the construction of facilities.

In general, operational contracting purchases are classified into three categories. The first category is services contracting. Examples of services contracting include the award and administration of housing maintenance, grounds maintenance, vehicle rental, and laundry service contracts. Service contracts also include less complex items such as repair of computers, office equipment, and other organizational support equipment (20:26).

The second category of operational contracting purchases is construction. Construction purchasing includes all contracts for the alteration, repair, and maintenance of existing facilities. Operational contracting squadrons may also award contracts for construction of new facilities valued under $200,000. Finally, construction activities include the award and administration of contracts with Architect-Engineering firms for design services (20:27).

The final category of operational contracting purchases is commodities. This category includes a variety of supplies and equipment (20:29). Supplies include office items, vehicle parts, medical stores, fuel, and other items needed to support the base mission. Commodity purchases also include items like computers, typewriters, and radiology equipment.

A typical contracting squadron consists of three flights which support each category of purchases. In addition, each squadron contains a fourth flight responsible for the Base Contracting Automated System (BCAS) and management information analysis. Finally, squadrons are managed by a Squadron Commander, Deputy Base Contracting Officer (BCO), and an Executive Officer/Non-Commissioned Officer.

The range of purchasing activities conducted by Air Force Operational Contracting Squadrons is enormous. In general, the squadron supports the entire mission of each

Air Force Base. An understanding of these varied responsibilities and their importance to mission objectives is critical to understanding the importance of measuring contracting performance.

<u>Importance of Performance Measurement in Operational Contracting</u>

As previously discussed, a primary reason for measuring operational contracting performance is its importance to supporting the mission of each Air Force Base. However, there are several other reasons which promote performance measurement of the operational contracting function. These reasons include items specific to the DOD and items which can be generalized across all contracting or purchasing organizations.

With expected budget and manpower constraints, improvements in performance are critical to maintaining current levels of defense. Specifically, each DOD function will be forced to find productivity improvements to offset budget reductions (53:10). Contracting squadrons must accomplish more with declining resources. Because operational contracting is a labor intensive service organization, increasing productivity is a desirable and achievable goal (59:28).

In an attempt to meet expected declines in budgets, the DOD is implementing the Defense Business Operations Fund

(DBOF). The initial implementation of DBOF began in fiscal year 1992 (28:45). Under DBOF, each mission support activity will eventually compete for business with other activities performing like functions. For example, a Wing Commander may choose between different Air Logistic Centers (ALC) for aircraft maintenance. The Wing Commander will be provided unit cost figures from each ALC and be able to choose the lowest cost service (53:11).

The cost information used under DBOF will be based upon unit cost measures. The prices charged for service functions will equate to a cost per unit of output (53:11). If a service providing function can increase its productivity and efficiency, it will lower its unit cost and become more competitive. The alignment of costs to outputs will force decision-makers to reduce costs by changing the output or changing the process which generates the output (53:11).

Although DBOF is not fully implemented, operational contracting squadrons may eventually fall under this program. The long range goal of DBOF is to bring all mission support activities into the fund (53:11). Performance measurement will be critical to improving productivity and lowering operational contracting costs. Lower costs would allow a contracting squadron to keep its current level, or even increase its customer base.

The importance of measuring contracting performance is not restricted to the DOD. A study of purchasing managers by van Weele revealed five general reasons for measuring purchasing performance. Each reason, along with an appropriate operational contracting example, is provided in Table 2.1.

TABLE 2.1 Reasons For Measuring Purchasing Performance

1. Purchasing performance evaluation can lead to better decision making. It identifies strengths, weaknesses, and variances from planned results. These problems can be analyzed and then prevented in future operations. In the operational contracting squadron, management could compare measured Contract Administration Lead Time (CALT) against an established goal.
2. The measurement of purchasing performance may lead to better communication with other departments. An example is analyzing payment conditions with financial management and deciding on specific payment procedures to improve mutual understanding. In the Air Force, operational contracting performance evaluation may lead to better receiving operations in the Base Supply Squadron or a more efficient method of payment with Accounting and Finance.
3. Measuring purchasing performance makes things visible. "The regular reporting of actual versus planned results enables a buyer to verify whether his or her expectations have been realized" (56:18). In operational contracting this feedback is not limited to the buyer, but also provides performance feedback to all levels of management.
4. Performance evaluation may contribute to better motivation. A well designed evaluation system can be used in a constructive goal setting, motivational, organizational, and personnel development program. The ability for an operational contracting squadron to obtain a performance measure can motivate toward a continuous process of improvement.
5. Purchasing performance evaluation should result in a higher added value of the purchasing function to the firm. For operational contracting, this higher added value may include lower operating cost, lower service and supply costs, better sourcing decisions, and a myriad of other process improvements.

(56:18)

After establishing reasons for measuring performance of operational contracting squadrons it is necessary to review a definition of purchasing performance. This definition concentrates on concepts of effectiveness and efficiency.

A Definition of Purchasing Performance

The performance of an operational contracting squadron is contingent on two primary concepts. A squadron can be considered a good performer if it is effective and efficient. Additionally, effectiveness and efficiency are not mutually exclusive. "Whether a certain result should be considered as effective or efficient varies depending on the aggregation level from which the matter is perceived" (56:19). For example, the Chief Executive Officer of a company may perceive lowering the purchasing department budget as a measure of efficiency while the purchasing agent may believe it is a measure of effective operations.

Purchasing effectiveness is defined as the ability to meet a previously established goal or standard. Effectiveness is a concept which refers to the relationship between actual and planned performance of any activity (56:19). In operational contracting, specific goals may be established at all levels of management.

Purchasing efficiency is the relationship between "planned and actual sacrifices made in order to realize a goal previously agreed upon" (56:19). Efficiency is a concept closely related to productivity. Productivity is often considered to be the actual ratio of outputs produced by an organization compared to the inputs used to create the output (42:420). The American Productivity Center defines productivity as a ratio of quantity of output to quantity of input for a given process (47:1). An operational contracting example of productivity or efficiency may be the number of purchase orders awarded per buyer.

This research concentrates on measuring operational contracting performance as it relates to productivity and efficiency. Many effectiveness goals for Air Force operational contracting are pre-established. For example, the Federal Acquisition Regulation specifies the use of competition to the maximum extent possible and each major command establishes a goal for the use of competitive purchase procedures. The operational contracting squadron's main objective is to produce the maximum output using the lowest level of inputs.

After establishing a general working definition for purchasing performance evaluation, it is necessary to review current methods used to measure contracting performance. This review concentrates on techniques used and their corresponding weaknesses. The review is divided in two sections. The first section describes current methods used by the Air Force to measure operational contracting squadrons. The second section covers other techniques used to measure purchasing performance in the private sector.

Current Operational Contracting Performance Evaluation

The current methods of evaluating operational contracting performance include four primary techniques.

These techniques are the Self-Inspection, the Command Inspector General (IG) visit, Air Force and Major Command Goals, and the use of BCAS measures. Each technique produces advantages and disadvantages for the operational contracting manager.

The Self-Inspection. Operational contracting self-inspection may be local management's single most effective management tool for assessing the health of the organization (20:101). A good self-inspection program integrates IG findings, IG crossfeeds, and command inspection guides into a checklist used by the operational contracting squadron. The strength of a self-inspection rests with the squadron's ability to review its operations when management determines the need.

However, the self-inspection process has several inherent weaknesses. First, it is normally a compliance based management technique. Checklists normally address yes or no type questions. For example, a self-inspection checklist may ask whether the proper documentation to dissolve a small business set-aside is present in a purchase order. This compliance based review provides little feedback on productivity and efficiency in operational contracting squadrons.

Second, the self-inspection program provides a limited ability to compare squadron performance with other contracting squadrons. A self-inspection may include how well the squadron is performing when compared to a checklist. However, this inspection often fails to provide performance feedback relative to other squadrons.

Finally, the feedback provided through a self-inspection is directly related to the number of man-hours required to complete the process and the experience level of the inspectors. A self-inspection requires removing manpower from purchasing activities. During periods of high purchasing activity there is an incentive for less effort in pursuit of a quality self-inspection.

The Command IG Visit. The IG visit is a formal evaluation of operational contracting performance. The results of the IG inspection become a matter of official record (20:106). Like a self-inspection, the IG review is a compliance based process. The IG performance evaluation concentrates more on issues of compliance with Federal Acquisition Regulations than on actual indicators of efficiency and productivity. This is not to imply that compliance with applicable procurement law is not important, but the process of efficiently using available resources to produce output receives little attention under IG review.

The IG process does provide the operational contracting squadron with relevant feedback in a formal report (20:109). However, the frequency of management feedback is relatively low. IG inspections usually occur once every twelve to eighteen months. By the time a performance problem is identified by the IG, the contracting squadron may have been conducting less than optimal operations for quite some time.

Air Force and Major Command Goals. Each fiscal year, the Air Force and its Major Commands develop specific goals to judge operational contracting performance. These goals concentrate on the areas of competition and support of socio-economic objectives. For example, each squadron is judged against a competitive purchase objective and a small business usage standard established by higher management.

These goals do provide some measure of performance against other contracting squadrons. However, the range of contracting functions measured is relatively limited. The data measured is objective in nature, but these goals provide little feedback concerning productivity or efficiency. The ability to award a majority of purchases to small business concerns says little about the efficient use of resources to produce outputs.

BCAS Measures. The development of BCAS has provided a significant area of improvement over previous operational contracting management information systems. This system provides on line and real time processing of contracting activity (45:14). Like most management information systems, BCAS is not without its data problems, but it does provide management with timely feedback on operations.

BCAS provides the manager with a myriad of individual performance indicators. For example, the BCAS Contracting

Activity Report (HAF-RDC M&A 7106) provides more management data than any other single report in BCAS (45:130). As of 1 October 1992, the 7106 report generated one hundred fifty five individual indicators of contracting performance. Examples of these indicators include total dollars obligated, total actions executed, and total small business dollars awarded.

The large number of possible measures available from BCAS is an indicator of its drawbacks. There is no method for an operational contracting manager to determine overall performance with such a large number of individual measures. Additionally, relative comparison between different squadrons is not possible under the current system.

Additional Techniques Available to Measure Purchasing Performance

In addition to the techniques currently used to measure operational contracting performance, two alternate methods are available. These methods are the use of ratio analysis and multiple regression (49:8). Each of these methods have been well tested in practice and management literature. Both have drawbacks which limit their use in the purchasing environment.

Ratio Analysis and Extensions. Ratio analysis and the use of accounting measures of efficiency are currently used by commercial industries to measure purchasing productivity

(58:46). Additionally, limited use of ratio analysis is used by operational contracting managers. For example, a comparison may be made of the number of contracting actions awarded per purchasing employee. Other examples of singular accounting measures include the ratio of competitive actions awarded to the total actions awarded, the average Contract Administrative Lead Time (CALT), or the percentage of total dollars awarded to small business concerns (45:31).

The use of ratio analysis has serious shortcomings. First, ratio analysis fails to account for differences between each organization (49:8). For example, differences in contracting squadron mission, size, complexity of purchases, and quantity and quality of human resources are difficult to account for under ratio analysis. This makes meaningful comparisons difficult because no two operational contracting squadrons are the same. Second, ratio analysis is limited to an examination of single combinations of resources and outputs. Service providers, such as operational contracting, have numerous resources and outputs which are important to overall performance.

To account for the multiple input and output characteristics of a service provider, analysts often compute several ratios simultaneously (49:9). Recently, Air Combat Command (ACC), has implemented a spreadsheet collection of several individual ratios of operational contracting performance (55). Currently, no method exists to combine these individual ratios into a single index of performance. When examined collectively, ratio measures "present a morass of numbers that give no clear indication of true efficiency" or overall performance (49:9).

To depict the problem presented by ratio analysis, a hypothetical example has been adopted from Sexton for the operational contracting environment (49:2). The following example of four operational contracting squadrons will be revisited in the Chapter III discussion of methodology. Listed in Table 2.2 are each squadron's resources and outputs generated over the past year.

TABLE 2.2 Hypothetical Resources and Outputs

	# of buyers	Operating budget	Total actions	Total dollars
Base A	6	2,000	4,000	15M
Base B	4	5,000	3,000	12M
Base C	10	8,000	6,000	20M
Base D	10	3,000	10,000	18M

These two inputs and outputs could be used to form several areas of ratio analysis. Three examples are presented in Table 2.3. Squadron rankings are provided in parenthesis.

TABLE 2.3 Example Ratio Analysis

	Actions per buyer	Dollars per buyer	Dollars spent per dollar of operating budget
Base A	666.7 (2)	2.5M (2)	7,500 (1)
Base B	750 (1)	3.0M (1)	2,400 (4)
Base C	600 (3)	2.0M (3)	2,500 (3)
Base D	300 (4)	1.8M (4)	6,000 (2)

Based on the example ratio analysis, it is impossible to identify which hypothetical contracting squadron is most productive or efficient. For example, when analyzing actions per buyer and dollars per buyer, Base B is the most efficient. However, Base B is the least efficient when analyzing dollars spent per dollar of operating budget. In the dollars spent per dollar of operating budget category, Base A is the most efficient, but it ranks second in actions per buyer and dollars spent. Which base is the most efficient overall? This simple example demonstrates the weaknesses caused by the inability to collectively analyze multiple ratios (49:20).

In an effort to overcome problems with basic ratio analysis, two alternate measurement techniques have been used by purchasing management. First, attempts have been made to benchmark singular performance measures to provide meaningful comparisons between purchasing functions within a particular industry. The purchasing benchmark project of the Center for Advanced Purchasing Studies (CAPS) has begun to gather purchasing data from firms in selected industry groups. When the data is collected and the industry group benchmarked, individual firms can compare performance against a standard for each purchasing performance measure (39:77).

The primary drawback to the benchmarking technique is identical to problems with standard ratio analysis. A meaningful measure of overall productivity is not possible using individual benchmarks for comparison. Attempting to address this problem, the Six Sigma Barometer was developed by the Digital Equipment Corporation (36:7). The Six Sigma Barometer attempts to aggregate individual performance measures into a single index of overall performance through the use of an a priori weighting scheme (36:10).

The critical drawback with this combination technique is the relative importance of each individual measure varies from firm to firm. In the operational contracting example (Table 2.3), the actions per buyer measure may be more important for Base B than for Base D. In summary, the required weight for each measure will vary upon the mission requirements of the contracting squadron, and the level of management deciding on appropriate weights (11:64).

The general difficulty of using combinations of singular performance measures is the requirement for each contracting squadron to use the same weighting factor for each measure. The weight chosen will be a compromise of perceived importance of each measure by the contracting squadrons and those performing the evaluation. A single weighting scheme is derived to account for the entire range of possible functional responsibilities, organizational goals, and types of purchases. If these factors vary from squadron to squadron, the resulting performance index will inaccurately reflect true purchasing efficiency. Finally, the ratio analysis technique and extensions do not provide contracting managers information concerning which areas of performance to change in order to improve overall efficiency (39:8).

Multiple Regression. As an alternative to ratio analysis, multiple regression is frequently used to measure performance in a service providing industry. Most often, a model is constructed with some output measure as the dependent or Y variable and various input measures as the independent or X variables (49:9). In the previous example of two contracting inputs and two contracting outputs, a single output may be modeled against two inputs. Data from all operational contracting squadrons would be collected and used to create a predictive equation. For example, the total dollars awarded may be the dependent variable and the operating budget and number of buyers may be the independent variables as shown in Equation (1).

$$\text{Total dollars} = \beta o + \beta 1^{*}(\text{oper. budget}) + \beta 2^{*}(\#\text{ of buyers}) + e \qquad (1)$$

In this example, the regression technique can provide an estimated relationship that could be used to predict the total dollars awarded based on operating budget and number of buyers (49:9). If a particular contracting squadron was relatively efficient, the actual total dollars awarded would exceed the level predicted by the regression model. In mathematical terms, the error term of efficient squadrons would be positive. Conversely, a relatively inefficient squadron would have a higher predicted value than actually exists and therefore a negative error term.

There are a number of theoretical drawbacks to the multiple regression technique. These theoretical problems can be translated into difficulties which operational contracting squadrons would face if the regression technique was employed. These problems are outlined below:

1. Single equation regression analysis would require that only one output be used as the dependent variable. If more than one output is desired, the analyst must combine multiple outputs into one measure. In the hypothetical example, the total actions and total dollars would have to be combined using some type of a priori weighting scheme (49:9).

2. Using the error term as the efficiency measure, the regression analysis would measure productive efficiency of contracting squadrons relative to average performers as opposed to the best performers. This average measure would provide contracting managers with diluted information concerning possible productivity gains (49:9).

3. The use of regression analysis would require the a priori specification of a parametric production function. The appropriate form of the operational contracting production function must be created prior to evaluation. Are the inputs combined in a linear, exponential,

multiplicative, or log fashion when creating outputs? An improper decision in the model creation stage would introduce specification bias into the results (25:180).

The specific weaknesses of using ratio analysis, extensions of ratio analysis, and multiple regression to measure operational contracting performance arise from the nature of the contracting function. Contracting managers have difficulty measuring resource inputs and process outputs. Once measured, the combination of these multiple inputs and outputs into a single meaningful index becomes difficult. Which performance attributes are the most critical? How should differences in mission objectives, complexity of purchases, and organizational characteristics be taken into account? The first step in understanding these problems can be found by examining performance measurement difficulties in public agencies and problems associated with measuring service organization performance.

Performance Measurement Difficulties in Public Agencies

The difficulties of measuring productivity or efficiency in the public sector have been well documented. The general problem can be classified into several specific areas related to a lack of quantifiable measures and difficulty in estimating a public agency production function. The same measurement problems identified in previous literature are applicable to the public agency function of operational contracting.

Lack of Quantifiable Measures. The first problem of measuring public agency performance is the general difficulty in determining profit. Some argue public sector managers, because they do not make profits, are less efficient than private sector counterparts (46:74). Independent of this argument is the fact that a measure of profit is the key factor in establishing effectiveness criteria in private organizations (3:40). In a profit-oriented firm, management decisions and performance evaluations are based on the attainment of profit.

Military organizations, including the operational contracting squadrons, are service-oriented operations. Profit is not the primary objective and management decisions are often made on the criteria of providing the best possible service with available resources (3:35). Current operational contracting performance can not be linked to profit because it operates as a public agency service provider.

Without a relevant measure of profit, public agencies may look for alternative indicators of performance. Because these agencies usually produce a service, it is difficult to quantify the output produced by sector enterprises. How does an analyst quantify the amount of education produced by a school (46:75)? How can operational contracting managers measure the level of service provided to their respective base? Examples of public sector and service providing functions are provided below:

1. A 1992 study by Murphy demonstrated measurement problems present in the petroleum industry purchasing function. Results demonstrated a lack of understanding concerning the relationships of various purchasing performance variables, both to each other and overall purchasing performance (39:79).

2. A 1984 study by van Weele identified three specific problems in measuring and evaluating purchasing performance. First, there exists a lack of formal objectives and performance standards for purchasing. Second, purchasing is not an isolated function, resulting in difficulty identifying direct input-output relationships of the process. Third, there exists differences in the scope of purchasing. Purchasing tasks and responsibilities may differ between different organizations (56:18).

3. Many public sector organizations have problems defining programs and complex tasks to perform. For example, public health agencies have a hard time specifying the correct type and amount of therapy to apply to a patients symptoms (4:194).

4. A 1991 study by Ray recognized the fact that inputs and outputs of public schools included items which contained limited amounts of economic meaning. Input measures

included classroom teachers per pupil, support staff per pupil, and administrative staff per pupil. Output measures included student scores on proficiency exams (44:1625).

5. When examining the efficiency of highway maintenance patrols, Cook et al. addressed the need to develop a measurement technique capable of handling non-economic factors. These factors included average age of pavement, number of accidents, and traffic volume per day (17:114).

Difficulty Estimating a Service Sector Production Function. The previously examined problems, caused by lack of quantifiable measures, relates to a larger theoretical problem when measuring public and service sector organizations. In economic terms, it is difficult to estimate a production function or appropriate production possibilities frontier in public organizations.

> Methods for evaluating the relative productivity of units in the public sector have lagged behind similar applications where production functions were more directly obtainable. (7:57)

The difficulty in establishing an appropriate production function, coupled with the measurement problems previously identified, lead researchers to look for an alternative technique for measuring performance.

Traditional economic theory defines a production function as the relationship between inputs and outputs where the quantity produced is equal to some function of various inputs. In the simple model, inputs would include a combination of labor and capital (40:235). In the contracting squadron, labor may include the number of buyers, capital may include the availability of computer usage, and an output may be the number of contracts awarded.

Microeconomic theory defines a production possibilities frontier as the alternative combinations of outputs that can be efficiently produced by a firm with a fixed quantity of resources (40:623). In the simple case of two outputs, a production possibilities frontier would take the shape of a convex curve as shown in Figure 2.1.

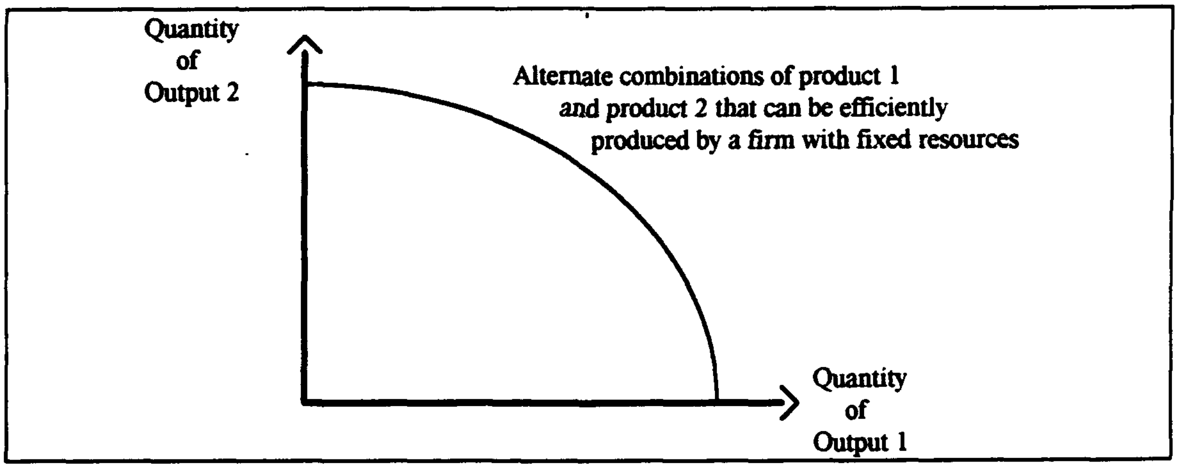

FIGURE 2.1 Production Possibilities Frontier

Economic theory suggests that any point along the production possibilities frontier is obtainable. The firm should produce at some point along the curve at all times unless it fails to allocate its resources in an efficient manner (54:213).

The difficulty arising from the use of the traditional production function and production possibilities frontier arises when the model is extended to the multiple input and output scenario. When the basic model is extended, accurate efficiency measurement can only be made if the actual production function is known prior to analysis (48:7). In the operational contracting example, a priori decisions must be made concerning the mathematical relationship between inputs and outputs.

The multiple input, multiple output problem was first addressed by M.J. Farrell in 1957 (23:253). The renewed interest in developing a working model to measure the production possibilities or efficient frontier was best stated in Farrell's original work:

> The problem of measuring the productive efficiency of an industry is important to both the economic theorist and the economic policy maker. If the theoretical arguments to the relative efficiency of different economic systems are to be subjected to empirical testing, it is essential to be able to make some actual measurements of efficiency. Equally, if economic planning is to concern itself with particular industries, it is important to know how far a given industry can be expected to increase its output by simply increasing its efficiency, without absorbing further resources. (23:253)

This statement by Farrell is critical for the operational contracting squadron. Contracting managers must be concerned with their performance relative to other squadrons. Additionally, decreasing DOD budgets will force contracting squadrons to increase or maintain output by pure increases in efficiency.

Charnes, Cooper, and Rhodes expanded the individual firm evaluations of Farrell to a multi-input, multi-output model for performance evaluation of multiple organizations with like functions (13:430). A linear programming technique to estimate the efficient frontier was termed Data Envelopment Analysis (DEA) (6:127).

DEA Overview

The specific DEA methodology is outlined in Chapter III. The purpose of this section is to introduce the reader to the basic concepts of DEA. This overview includes basic characteristics of DEA which make it an appropriate model to apply to the operational contracting environment. Finally, a discussion of previous DEA applications aids in establishing its usefulness for performance measurement in public and service providing organizations.

DEA is a mathematical programming technique used to measure productive efficiency, or productivity of each member of a set of comparable producing units. These units are termed Decision Making Units or DMUs. DEA measures productivity in a relative sense, that is each DMU is evaluated relative to its peers (49:7). The DEA technique converts multiple input and output measures into a single comprehensive measure of productive efficiency (22:90). The ability of DEA to incorporate several traditional ratio measures into a single performance measure makes it well suited for operational contracting application. In general, the DEA technique floats a piece-wise linear frontier to rest on the top of observations of DMU performance (48:8). This frontier is analogous to the efficient frontier in traditional economic analysis (Figure 2.1).

The specific characteristics of DEA make it an attractive alternative for measuring performance in public sector and service providing organizations (34:361). These characteristics, along with appropriate operational contracting examples, are provided in Table 2.4.

TABLE 2.4 Characteristics of DEA

1. Through DEA use, similar public sector DMUs such as schools and hospitals may be compared directly and evaluated in terms of relative efficiency even when they produce multiple outputs from multiple inputs.
2. DEA is appropriate for use when economic values for outputs and inputs are not easily identified. For example, it is difficult to place an economic price upon the number of contracts awarded or the level of competition obtained by an operational contracting squadron.
3. DEA is an extremal method for measuring performance. The process compares a DMU with the best performing DMUs, not a hypothesized or average performer.
4. Each DMU is evaluated based on what it does best. The resources and outputs which a DMU uses most efficiently will receive the highest possible weight from the linear programming solution. As contracting missions, functions, and purchase complexities vary between squadrons, DEA allows the assigned input and output weights to vary.
5. DEA does not require specification of the importance, rank, or weight for either inputs or outputs. This characteristic eliminates the subjective conflict which often arises over the value of public sector resources and outputs.
6. A DMU which is rated relatively inefficient is indeed strictly inefficient. A DMU is only inefficient if another DMU, or combination of DMUs, produces output at a lower unit cost.
7. Application of DEA, using controllable inputs or outputs, allows for the development of a management strategy for improvement. The results of DEA provide information regarding output increases or input reductions needed to achieve efficiency.
8. DEA input and output data can be used in raw form. In other words, there is no need to standardize data based upon units of measure.

(34:361-367)

The characteristics of the DEA technique make it a possible alternative to measuring performance in public and private service providing organizations. DEA has been tested empirically in many settings. DEA has been used to measure efficiency in hospitals (52; 57:185-205; 4:192-205), international logistics (29:3-14), education (1:165-185; 7:57-75; 44:1620-1628), and banking (24:229-245).

Recently, DEA has gained interest in both the military and purchasing environments. A 1992 study by Clarke evaluated the productivity of seventeen vehicle maintenance operations in Tactical Air Command (14:376). A 1986 study by Coyle attempted to apply the DEA technique to evaluation of the Air Force Environmental Program (18:3). Finally, a 1992 study by Murphy demonstrated DEA possibilities for capturing performance of a purchasing organization. In this study, DEA was applied to benchmarking type data from the purchasing functions in the petroleum industry. The DEA technique proved to be a more powerful tool than benchmarking or other existing methods to aggregate the data into a single index of overall performance (39:209).

Until now, the DEA technique has not been applied to Air Force operational contracting squadrons. The importance of tracking operational contracting performance, weaknesses in current methods of measurement, and the favorable characteristics of DEA make its use a logical addition to the contracting management function. The many examples of DEA in public and service providing organizations provide a solid foundation for applying the technique to operational contracting.

Chapter Summary

The literature review has provided an overview of the operational contracting function. The operational contracting squadron's primary objective is to procure supplies and services in support of mission requirements. A general working definition of purchasing performance was provided. This performance consists of the related concepts of effectiveness and efficiency. In the era of decreasing DOD budgets, managers must concentrate on efficiency improvements. Performance evaluation techniques currently available for use in operational contracting squadrons were discussed. Weaknesses of these approaches were highlighted along with general measurement difficulties present in public and service providing agencies. Finally, the DEA technique was introduced as a possible improvement for evaluation of operational contracting squadrons.

The results of the literature review indicated weaknesses in current methods to measure operational contracting performance. Current methods fail to account for differences in squadron characteristics, missions, and purchase complexity. Additionally, contracting managers can not combine singular performance measures into an aggregate measure of overall performance. Finally, feedback provided by current methods does not provide specific information on how to improve productivity and efficiency.

The recently developed DEA technique has the potential to improve on current methods of measuring operational contracting performance. As discussed in this literature review, the characteristics of DEA make it well-suited for operational contracting performance measurement. Specifically, DEA has the ability to measure performance in service providing organizations where it is difficult to place an economic price on inputs and outputs.

III. Methodology

Overview

The purpose of this chapter is to provide an explanation of the research design and related DEA methodology. Part I of this chapter provides a detailed description of the DEA methodology. Part I includes an introduction with DEA assumptions, a simple graphical example, and the development of the DEA linear program. This description is required before the various techniques used to answer specific research objectives and questions are discussed.

Part II of the chapter provides the various methods employed to answer each research objective. Specific techniques for answering each of the five investigative questions are contained in this part.

Part I: Data Envelopment Analysis

In an effort to overcome the drawbacks to traditional measures of productivity, outlined in Chapter II, Data Envelopment Analysis was chosen for examination as a possible alternative for measuring performance in the operational contracting environment. This section of the chapter introduces the reader to the concept of DEA and provides a detailed explanation of its application to operational contracting.

Introduction to DEA. Since DEA is the primary methodology employed in this research, a detailed explanation is provided as a first step in addressing the research problem of developing an alternate method of measuring operational contracting performance. The same hypothetical example of four contracting squadrons, introduced in the Chapter II review of common performance measures, is used to introduce DEA. Each squadron has two inputs and one output as shown in Table 3.1.

TABLE 3.1 Hypothetical Squadron Data

	# of buyers	Operating budget	Total dollars
Base A	6	2,000	15M
Base B	4	5,000	12M
Base C	10	8,000	20M
Base D	10	3,000	18M

The basic problem facing the analyst is to measure the relative productive efficiency, or productivity of each of the contracting squadrons. DEA would identify these squadrons as a set of comparable producing units. The term Decision Making Unit (DMU) is used to describe each contracting squadron (49:7).

DEA is a mathematical programming technique used to measure relative productive efficiency, or productivity of each of a number of DMUs (39:103). The technique is well-sui+ed for situations where there are multiple inputs and outputs to the process and there is no way to aggregate these inputs and outputs into a meaningful single performance index (49:10). Difficulties in aggregating inputs and outputs are inherent to the operational contracting function.

In the general sense, DEA is a linear programming method of estimating a production possibilities or isoquant frontier for a given set of DMUs (13:435). The technique "floats a piecewise linear surface to rest on the top of given DMU observations" (48:8). This surface defines the efficiency frontier from which comparisons can be made to determine the relative efficiency for each DMU (31:428). It is important to note that efficiency is determined relative to other DMUs and is not efficiency in the absolute sense. In the contracting example, each of the four squadrons will be compared to the other squadrons. DEA makes no attempt to quantify the squadrons absolute measure of productive efficiency.

As with any linear programming technique, DEA has a set of assumptions required for usage. These are extensions of standard linear programming assumptions. Before, proceeding with the DEA formulation, these assumptions must be addressed. A complete list of the DEA assumptions, with relevant operational contracting examples, is provided in Table 3.2.

TABLE 3.2 DEA Assumptions

1. DEA requires all relevant inputs and outputs be identified and measured in a consistent manner among all DMUs (49:27). In the operational contracting environment, inputs such as total dollars spent, must be measured the same way at different squadrons.

2. The inclusion of invalid inputs and outputs can cause a higher rating for some DMUs than they should receive. As variables are added, even if irrelevant, efficiencies will rise (39:140). This fact requires an appropriate method to identify relevant input and output variables. The method of choosing variables for the operational contracting analysis is discussed in Part II of this chapter.

3. As the number of DMUs (n) decrease, relative to the number of inputs (m) and outputs (s), the number of relatively efficient DMUs increases. This arises because DEA solves a linear program with (n+1) constraints in (m+s) dimensional space. When (m+s) is large relative to n, it is likely that many DMUs will find their optimum solution along the boundary of their own constraint, since there are few other constraints to make the solution feasible (39:141).

4. DEA assumes that each unit of a given input or output is identical to all other units of the same type among DMUs(49:28).

5. In working with a piecewise linear frontier, it is assumed that all potential points along the frontier are feasible. In other words, it is assumed that there is continuous substitutability of one input or output for another, such that every point on the line segment of the efficient frontier could be achieved (22:113).

6. DEA addresses the concept of relative technical efficiency only. A DMU is technically efficient if it maximizes output for a given level of inputs (39:144). In the operational contracting example, each squadron is compared relative to the best performing squadrons and not a pre-established concept of absolute efficiency.

7. DEA assumes there are constant returns to scale. Proportional changes made in all the input levels will result in changes of equal proportions in the output level. In other words, the weights DEA generates for inputs and outputs are constant over the range of possible alternatives (49:28).

8. DEA observes relative efficiency only. If all DMUs are inefficient in an absolute sense, DEA will not capture the inefficiencies (39:146).

9. Input and output weights produced by DEA can not be interpreted as values in the economic sense. DEA does not create economic unit values for inputs and outputs, they are only used to measure relative efficiency (49:28).

These assumptions provide some DEA limitations, but one powerful characteristic of the technique is its ability to examine several inputs and outputs simultaneously. In the operational contracting environment, various inputs and outputs could be included in the DEA analysis. Examples of possible outputs include total number of items purchased or contract administrative lead time (CALT). Possible input examples include the number of purchasing personnel or average personnel experience. With this characteristic in mind, the first step in understanding DEA is to examine a two input, single output example. This simplified example aids DEA understanding by allowing for a graphical solution.

A Graphical Example. Using the hypothetical example previously introduced (Table 3.1), a graphical approach can be used to explain DEA. Each contracting squadron is now identified as a DMU. The single output is the total dollars awarded (in millions). The two inputs are the operating budget (in thousands) and the number of buyers. Each DMU takes the inputs, and through the contracting process, generates an output. The process is shown in Figure 3.1.

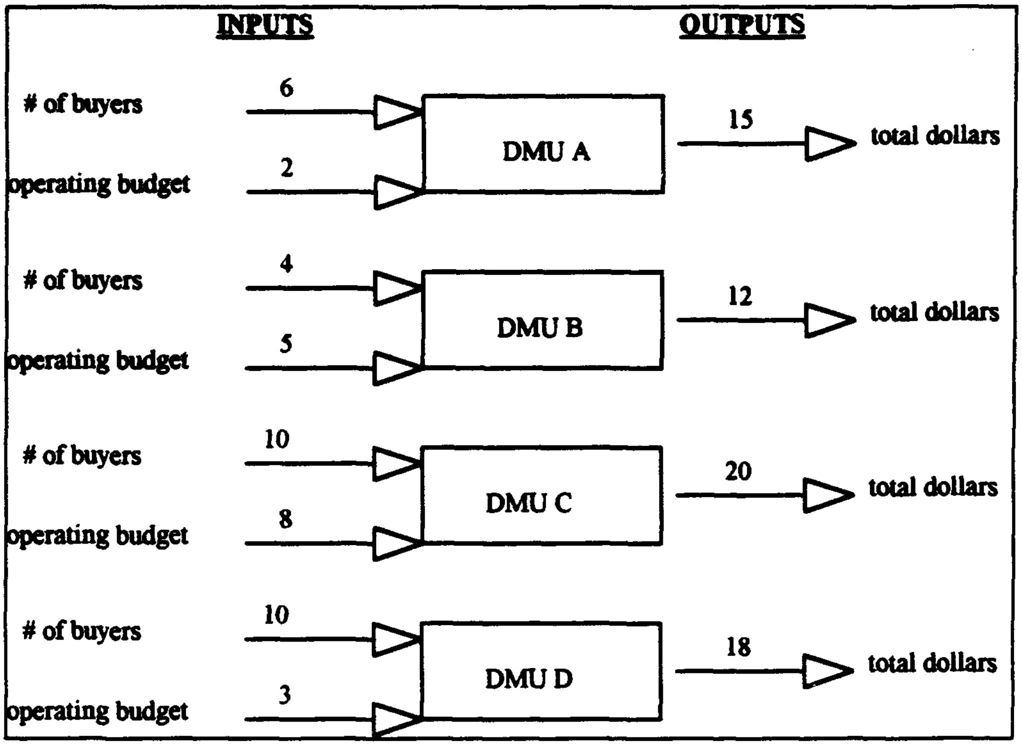

FIGURE 3.1 Operational Contracting Process

The DEA technique is employed in the same manner as traditional linear programming methods. The analyst can maximize outputs for a given input level, or minimize inputs used for a given output level. In the graphical example, inputs are minimized for a given level of output. The first step is to normalize the data so the inputs are expressed in terms of a single unit of output. The result of normalizing the inputs is shown in Table 3.3.

TABLE 3.3 Normalized Input Levels

DMU	input 1/output # of buyers/total dollars	input 2/output operating budget/total dollars
A	6/15 = .40	2/15 = .13
B	4/12 = .33	5/12 = .42
C	10/20 = .50	8/20 = .40
D	10/18 = .56	3/18 = .17

Once the normalized input values are obtained, the results can be presented in graphical form. The result of plotting the normalized inputs per single output is an efficient frontier for the contracting DMUs (49:13). The plot of the normalized input levels is shown in Figure 3.2.

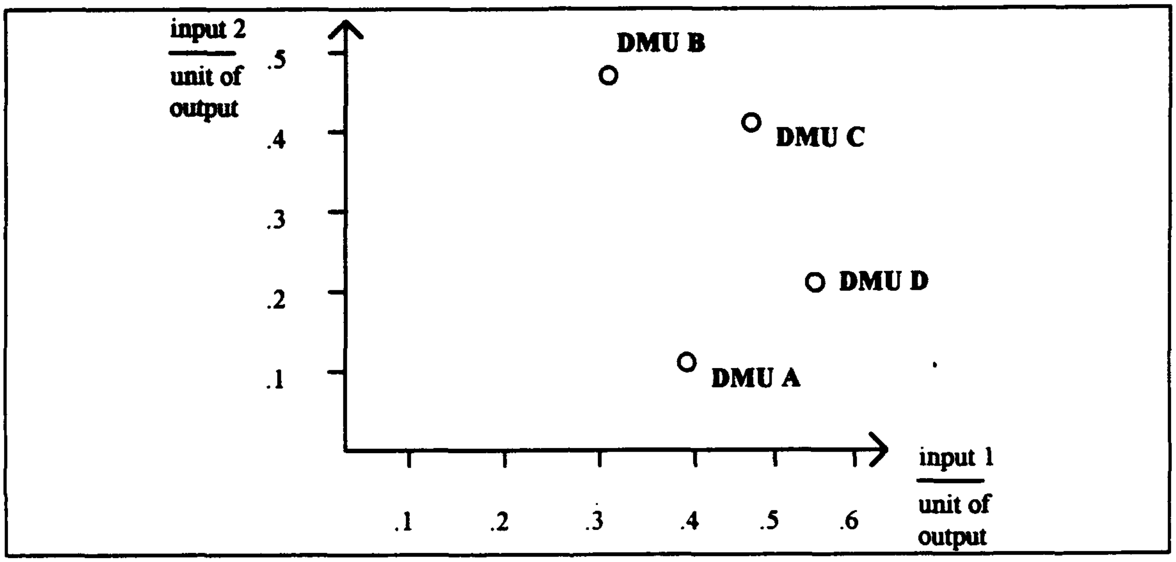

FIGURE 3.2 Normalized Input Plot

Determining the Efficient Frontier. When the DEA goal is to minimize inputs for a given level of output, any DMU that is lower and to the left of another DMU is more efficient. This results because the efficient DMU is producing the same level of output using lower levels of input. In the minimization problem, the ultimate goal of each DMU is to move as close to the origin as possible (49:13). In the hypothetical example, DMU A and DMU B form the efficient frontier. They will receive the maximum efficiency rating of 1.0. Once the frontier is formed, all other DMUs can be examined relative to their location away from the frontier. A graph of the complete DEA efficient frontier is provided in Figure 3.3.

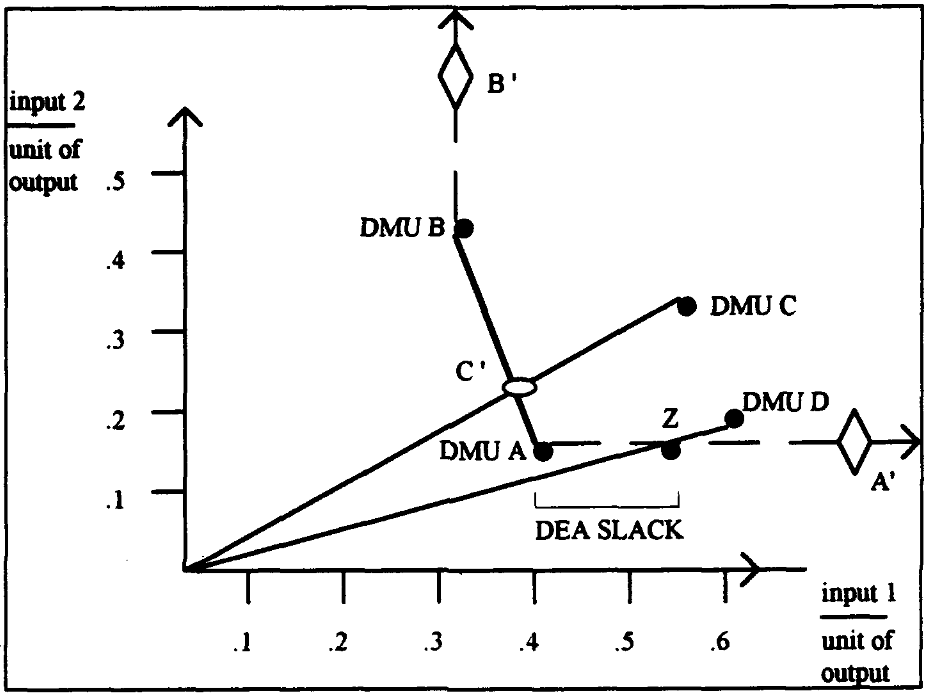

FIGURE 3.3 Complete DEA Efficient Frontier

Examining Inefficient DMUs. After identifying DMU A and DMU B as the squadrons which form the efficient frontier (the line segment joining DMU A and DMU B), an examination of inefficient DMUs must be made. This examination includes DMU C and DMU D from the graphical example.

DMU C. In order to examine the efficiency rating of DMU C, a line segment is constructed from the origin so it passes through the efficient frontier and connects to DMU C. The point C' indicates where the line segment crosses the efficient frontier. To determine the relative efficiency of DMU C, the length of line segment 0C' is compared to the length of line segment 0C. When 0C' is divided by 0C, a ratio less than one results (49:15). This ratio indicates the relative efficiency of DMU C. For example, the ratio of 0C'/0C equals .726. It can be said DMU C receives an efficiency rating of 72.6%.

The information provided by the graphical example is not limited to a raw efficiency score. The point C' corresponds to a "hypothetical DMU whose input mixture ratio is the same as that of DMU C" (49:15). In the example, the hypothetical DMU C' uses the same mix of buyers and operating budget as the inefficient DMU C. In a broader sense, DMU C and the hypothetical DMU C' use the same production technology. This concept allows DMU C to use DMU C' as a model for improvement.

The hypothetical DMU C' is a combination of the two efficient DMUs which dominate DMU C. In this example, DMU A and DMU B dominate DMU C. DMU C' is a weighted average of DMU A and DMU B. In DEA terminology, it is said DMU A and DMU B form the efficiency reference set for DMU C (49:15). Only efficient DMUs can form the efficient reference set for an inefficient DMU.

<u>DMU D</u>. The analysis of DMU D is not as simple as that for DMU C. DMU D does not lie on the efficient frontier. Moreover, DMU D is not dominated by a linear

combination of the two DMUs on the efficient frontier (8:787). In the graphical example, a line can not be drawn from the origin to DMU D which passes through the efficient frontier. The occurrence of a point such as DMU D is referred to as an "unenveloped solution" (8:788). When an unenveloped solution occurs, the researcher must proceed with caution. The basic DEA will identify DMU D as an efficient DMU. However DMU D could have received the same rating while using fewer inputs (8:789). To combat this problem, three techniques can be employed.

First, the efficient frontier could be extended vertically from the uppermost DMU and horizontally from the lowermost DMU. These extensions correspond to points B' and A' on the graphical example. These extensions serve to provide a complete efficient frontier for analysis. However, DMU D is not dominated by two DMUs and a second DMU must be created. In the graphical example, classical DEA of DMU D involves the creation of an arbitrary DMU along the horizontally extended frontier. In this example, it would be point Z and the efficiency rating for DMU D would be the ratio of line segment OZ divided by segment OD (8:789).

The second method of examining unenveloped solutions involves the same concepts as vertical and horizontal frontier extension. When the frontier is extended vertically and horizontally from the uppermost and lowermost DMU, it is possible to have a DMU at point B' or point A' which receives an efficiency score of 1.0. The horizontal and vertical frontier extension would classify these new DMUs as efficient, even though the new DMUs would be using more of an input, while producing the same output as DMU B or DMU A. Because of a greater use of an input, these types of DMUs should not be considered efficient (49:14).

This problem can be avoided by a redefinition of the efficient frontier. Instead of using a vertical and horizontal extension, the frontier can be extended to points on the vertical and horizontal axis at infinity. This extension results in the highest segment of the efficient frontier sloping slightly to the left. Point B' would no longer fall on the frontier. Using the same technique, the lowest segment of the frontier slopes slightly downward. Point A' is no longer classified efficient (49:16).

The third approach to solving for unenveloped solutions is the recently developed extension of DEA called Constrained Facet Analysis (CFA). CFA was originally proposed in 1984 by Bessent, Bessent, Elam, and Clark (8:785). The technique attempts to provide a lower bound efficiency measure for DMUs that have a mix of resources and/or outputs which differ from frontier points (8:785). CFA extends the frontier through a mathematical algorithm which attempts to envelop all DMUs.

<u>Method Chosen to Analyze Unenveloped Solutions</u>. The proposed CFA extension will not be used in the current DEA

formulation. Instead, if an unenveloped solution is encountered, it will be identified by examining the efficiency reference set (ERS) of all DMUs. Only operational contracting squadrons on the efficient frontier can appear in the ERS of inefficient squadrons. Contracting squadrons which are rated efficient, yet do not appear in the ERS of another squadron, may have a slack value in one or more of the inputs (39:182). If a slack value is discovered, the contracting squadron could have produced the same level of output with lower levels of identified slack inputs. In other words, those squadrons rated efficient, but not in the ERS of another squadron, and containing slack in one or more inputs, should not be considered efficient (39:182). An examination of all ERS and associated slack values will identify squadrons which could have achieved the efficiency rating of 1.0 while using fewer inputs.

This approach is analogous to the graphical example of extending the efficient frontier to points on the vertical and horizontal axis at infinity. This analogy results from the ability to identify unenveloped solutions by examining the ERS of all DMUs. The use of this technique increases the quality of information provided from the DEA model.

The DEA Formulation

The previous section demonstrated the DEA concept using a simple two-input, single-output example. The graphical example provides a basic understanding of the methodology, but it can not be extended to a multiple-input, multiple-output scenario. Fortunately, the model can be formulated into an analytical technique which can be solved using most linear programming software packages. This section explains the linear programming formulation for the DEA methodology.

In order to understand the model formulation, the decision variables and constants require description. Instead of the four DMUs in the graphical example, there are now "n" DMUs. Each of these DMUs uses "m" inputs to produce "s" outputs. X_{ij} is the amount of input "i" used by DMU_j. Y_{rj} is the amount of output "r" produced by DMU_j. The decision variables of interest are the unit weights attached to each of the inputs and outputs used by DMU_j. V_{ij} is the unit weight placed on input "i" by DMU_j. V_{rj} is the unit weight placed on output "r" by DMU_j (49:17).

With the constants and decision variables outlined, the next step is to formulate a total of "n" fractional linear programs. A single fractional linear program is formulated for each DMU. The specific DMU being evaluated is designated as DMU_o (39:121). The objective function of the fractional linear program is the ratio of the total weighted output of DMU_o divided by its total weighted input (13:430):

$$\text{Maximize } H_o = \frac{\sum_{r=1}^{s} U_{ro} Y_{ro}}{\sum_{i=1}^{m} V_{io} X_{io}} \qquad (2)$$

Each DMU must choose its unit weights subject to the constraint that no other DMU would have an efficiency rating greater than one if it used the same weights. In other words, a DMU which is more efficient than DMU_o will receive DEA rating of 1.0 while DMU_o will be forced off the efficiency frontier and receive a DEA rating less than 1.0. This provides a fractional constraint such that (13:430):

$$\frac{\sum_{r=1}^{s} U_{ro} Y_{rj}}{\sum_{i=1}^{m} V_{io} X_{ij}} \leq 1;\ j=1,2,\ldots n \qquad (3)$$

The final two constraints stipulate that the selected unit weights can not be negative. These constraints are formulated such that (13:430):

$$U_{ro} \geq 0;\ r=1,2,\ldots s \qquad (4)$$
$$V_{ro} \geq 0;\ i=1,2,\ldots m \qquad (5)$$

<u>The Charnes, Cooper, Rhodes (CCR) Transformation</u>

In Chapter II, Charnes, Cooper, and Rhodes were given credit for developing the DEA technique. This credit includes a transformation method to permit use of the simplex solution algorithm. The above model (equations 2-5) is an extended nonlinear programming formulation of an ordinary fractional programming problem (13:431). It requires a linear transformation in order to solve using ordinary simplex linear programming.

The detailed steps of the CCR transformation are not required for understanding of the DEA methodology. The CCR transformation replaces the extended nonlinear fractional programming problem with an ordinary linear programming problem. This linear program is the DEA methodology used in this research. The model is shown in equations 6-10 (13:432):

$$\text{(DEA)} \qquad \text{Maximize } H_o = \sum_{r=1}^{s} U_{ro}\, Y_{ro} \tag{6}$$

Subject To:

$$\sum_{r=1}^{s} U_{ro}\, Y_{rj} - \sum_{i=1}^{m} V_{io}\, X_{ij} \le 0; \; j=1,2,\ldots n \tag{7}$$

$$\sum_{i=1}^{m} V_{io}\, X_{io} = 1 \tag{8}$$

$$U_{ro} \ge 0; \; r=1,2,\ldots\; s \tag{9}$$

$$V_{io} \ge 0; \; i=1,2,\ldots\; m \tag{10}$$

Equation (6) is the objective function of the DEA methodology employed in this research. Equations (7) through (10) form the constraints. Taken together, these equations form the DEA technique which can be solved through the ordinary simplex algorithm (13:429). In simple terms, the objective function (6) attempts to maximize the weighted outputs of DMU_O. The first constraint (7) states that using DMU_O's weights, the sum of the weighted outputs minus the sum of the weighted inputs for all DMUs in the model, must be less than or equal to zero. The second constraint (8) stipulates the sum of the weighted inputs for DMU_O must equal one. The final two constraints (9 & 10) ensure the weights are assigned some value greater than or equal to zero.

Complete DEA Analysis

A complete DEA requires the solution of "n" linear programs, one for each DMU, using the transformed function and constraints. These linear programs are similar to each other. The only difference is in the objective function coefficients and specification of the last constraint. This characteristic makes the computational effort required to solve the DEA problem relatively simple after initial model specification (49:18).

Once the DEA solution is obtained, the output provides the analyst with information concerning relative efficiency, the use of resources to produce output, and methods for performance improvement. The nature of linear programming provides this information in the form of the weights (coefficients) assigned to the decision variables and the dual (slack) solution. The results of the DEA application to operational contracting squadrons are presented in Chapter IV.

Part II: Specific Objectives and Investigative Questions

A complete introduction to the DEA methodology was required before addressing the specific techniques employed to answer the research objectives and related investigative questions. The DEA technique was the critical factor driving the chronological use of five investigative questions for meeting the research objectives. Part II of this chapter addresses the specific investigative questions and identifies techniques used to provide solutions.

Investigative Questions 1 & 2: What are the Most Critical Outputs and Resources? The first step in developing the DEA model was to identify candidates for possible input and output measures. Within any DEA application, the selection of inputs and outputs is critical. Clarke suggests examining five characteristics of data when selecting possible input and output measures (14:377). These characteristics have been adapted to the operational contracting environment and are listed in Table 3.4.

TABLE 3.4 Characteristics of DEA Variables

1. Data should be regularly available to (or from) managers involved in operational contracting management.
2. Utilized data should be collected and reported in a consistent manner for all contracting squadrons.
3. Data reported in ratio form should be separable into numerator and denominator values so differences in scale can be identified when necessary.
4. Data should be numerical or easily converted into numerical form.
5. All numerical values should be managerially significant, meaningful, and readily understood by operational contracting management.

(14:377)

The data provided by the Base Contracting Automated System (BCAS) was reviewed in detail. All possible measures with the potential to meet Clarke's first four characteristics were identified and listed. A complete list of possible measures is included as Appendix A. The initial list revealed 155 possible measures.

The next step in identifying input and output measures was to determine the variables which were managerially significant. The original 155 possible measures were taken from the BCAS report entitled RCS HAF-RDC (M&A)7106, Base Contracting Activity Report (referred to as the 7106 report). These measures were screened by a group of eight former operational contracting managers. Each had managed within the last twelve months. The screening process was used to narrow the total number of items so a manageable and administratable survey could be developed. The screening process resulted in the selection of fifty one possible measures which could be meaningful, managerially significant, and readily understood by contracting management. A complete list of the fifty one possible measures is provided in Appendix B.

Once identified, these measures were incorporated into a survey using a five point Likert scale. The scale consisted of the following five points: (1) Definitely Not Important, (2) Somewhat Not Important, (3) Neutral, (4) Somewhat Important, (5) Definitely Important. Management literature often assumes a Likert scale, with a true neutral response, provides data with order and distance. In other words, the Likert scale is assumed to represent an interval scale (21:222) Once this assumption is made, the research can employ parametric statistics to measure central tendency and conduct hypothesis tests. There exists wide disagreement concerning this treatment of Likert responses as interval data (22:175).

The current research assumes interval data resulting from the survey to identify critical input and output variables. Parametric statistical tests were performed to identify those variables important to contracting managers. This assumption does not remove the possibility of inequality of intervals on the Likert scale (22:175). However, the only purpose of the survey was to reduce the 51 possible variables to those of relative importance. Once reduced, qualitative analysis was conducted in order to construct the final DEA model.

During survey construction, it was discovered that another thesis effort would be issuing a similar instrument to the same sample. In order to improve the response rate for both thesis projects and minimize effort on the part of respondents, the two surveys were combined into a single survey. A copy of the survey is included in Appendix C. All questions used for this thesis effort are typed in bold print.

The survey was pilot tested on a sample of ten former operational contracting managers. Their duties ranged from serving as the Squadron Commander to Chiefs of Contracting Flights. In addition to the pilot test, the survey was reviewed by personnel at the Air Force Logistics Management Agency at Maxwell AFB, AL (AFMLA/LGC). This organization was chosen because its mission is conducting management research concerning operational contracting performance.

Once pilot and review comments were incorporated, the survey was administered to the selected sample. Because a primary goal was to identify input and output measures which were managerially significant, the population of interest was all members of operational contracting management in the Air Force. In order to properly generalize the survey findings to this population, a modified method of quota sampling was used (21:275).

Two control dimensions were used for the quota sampling technique. The first dimension was a sample of all operational contracting squadrons within the Continental United States (CONUS). The decision to sample all 82 operational contracting squadrons eliminated problems associated with selecting random squadrons from the population. The second dimension was to specify management as specific job levels within each operational contracting squadron. The second dimension limited the sample to the top three management positions in each squadron. These positions include Squadron Commanders (also known as Base Contracting Officers (BCOs)), Deputy BCOs, and Squadron Executive Officers/NCOs. These positions were selected because they represent operational contracting managers with the responsibility of resource control and overall performance at each squadron.

Once management was identified, the survey was administered to a sample consisting of all operational contracting managers within the CONUS. The sample included management at all squadrons in Air Combat Command (ACC), Air Force Material Command (AFMC), Air Mobility Command (AMC), Air Force Space Command (AF Spacecom), and Air Training Command (ATC). The management sample included two hundred fifty eight possible respondents. In effect, this process reflected a census of the top three operational contracting managers.

After the management surveys were returned, two statistical techniques were used to identify critical input and output measures to use in the DEA application. First, the questions covering the 51 possible measures were rank ordered based upon the mean response. The variance and standard deviations were calculated for each question. These measures gave a general indication of the amount of dispersion in the responses to a given question. However, a more stringent technique was required to identify those variables meeting Clarke's fifth characteristic of managerial significance (14:377).

Because the survey included 258 possible respondents, a Large-Sample Test of Hypothesis About a Population Mean was chosen as the method to identify which of the 51 possible variables to include in the DEA model. The mean response for each question was compared to the Likert scale response of 4.0. A one-tailed test (α=.05) was employed in order to identify those variables whose mean response was significantly greater than the survey response indicating a somewhat important variable (37:356). An example of the Large Sample Test of Hypothesis is shown in Table 3.5.

TABLE 3.5 Large Sample Test of Hypothesis About μ

One-Tailed Test $\alpha = .05$
H_0: μ individual question = 4
H_a: μ individual question > 4
Test Statistic: $z = \dfrac{\bar{X} - 4}{\sigma_{\bar{X}}}$
Where: $\sigma_{\bar{X}} = \sigma/\sqrt{n}$
Rejection Region: $z < -z_\alpha$ (or $z > z_\alpha$ when Ha: $\mu > \mu_0$)

(37:356)

There are no assumptions required about the underlying probability distribution when using the Large Sample Test of Hypothesis. For large samples ($n > 30$), the Central Limit Theorem provides assurance that the test statistic will be approximately normally distributed. This theorem holds regardless of the shape of the underlying probability distribution (37:356). Additionally, the decision to test mean responses away from the Likert response of 4.0, insured the identification of truly important variables.

Once the original 51 possible variables were reduced using the Large Sample Test of Hypothesis, the managerially significant variables were further reduced through non-quantitative examination based upon Clarke's first four characteristics listed in Table 3.4. This reduction, using Clarke's characteristics, ensured only important variables, which managers could influence, were included in the DEA model.

Investigative Question 3: What are the Results of the DEA Application to Operational Contracting Squadrons? After identifying the input and output measures, the third research question was addressed. This question required the actual formulation of a DEA model based on the identified inputs and outputs. This methodology required execution of a linear program for each of the DMUs under analysis. The results of the DEA application are presented in tabular format. These results include the DEA or efficiency score for each contracting squadron and the ERS for each squadron receiving a score less than one. The concept and formulation of DEA was discussed in Part I of this chapter, however, a description of the archival data source is required.

All potential input and output measures were derived from data available on the BCAS 7106 report of each contracting squadron. Once survey results identified measures of greatest importance, the data was collected from 7106 reports from all ACC and AFMC bases for fiscal year 1992. This allowed application of the DEA model to forty five operational contracting squadrons ensuring a large sample of DMUs for analysis.

Investigative Question 4: What Information Does DEA Provide the Air Force Operational Contracting Manager? The answer to investigative question four was provided by interpreting the results of DEA for each operational contracting squadron. DEA provides the manager with information to aid in performance improvement. The purpose of investigative question four was to demonstrate the information DEA provides contracting managers in addition to the basic efficiency score and ERS. This information includes the four main areas listed in Table 3.6.

TABLE 3.6 Management Information Provided by DEA

1. The input and output weights assigned by DEA for each operational contracting squadron.
2. The comparison of relatively inefficient squadrons with its ERS by calculating the excess inputs used to produce the given level of output.
3. The calculation of a Hypothetical Comparison Unit (HCU) for each squadron receiving a DEA rating less than 1.0.
4. The method to examine improvement through reduction of a single input.

Each of these four areas of information provide managers with methods of improving performance. A complete discussion of how DEA generates the four areas of management information is provided in Chapter IV. In order to demonstrate how DEA generates this information, Wurtsmith AFB was selected as the contracting squadron to examine in

Chapter IV. The information for the remaining relatively inefficient squadrons is presented in Appendix D.

<u>Investigative Question 5: What Characteristics of a Performance Measurement System are Desired by Operational Contracting Managers and How are They Addressed by DEA</u>? The answer to this question was critical to determining DEA's potential use by operational contracting managers. The methodology employed to analyze this question was a two-step process. First, desirable characteristics of a performance measurement system were identified through the survey of operational contracting managers. The same survey used to analyze input and output variables contained eleven questions concerning desired characteristics. These questions allowed contracting managers to respond on the same five point Likert scale. The survey instrument is provided in Appendix C. A list of the eleven questions analyzed to determine management's desired characteristics of a performance measurement system are shown in Table 3.7.

TABLE 3.7 Survey Questions Responding to IQ 5

#	Question				
	Strongly Agree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5
8	The current Command IG evaluation system satisfactorily measures organizational performance.				
9	An evaluation system, different from the Command IG, would be useful in measuring overall organizational performance.				
#	**Question**				
	Definitely Not Important	Somewhat Not Important	Neutral	Somewhat Important	Definitely Important
	1	2	3	4	5
98	The current IG method of performance evaluation provides feedback to help improve performance which is?				
99	Current Command and Air Force awards provide feedback concerning performance which is?				
100	Improving operational contracting squadron productivity and efficiency is a goal which is?				
101	A contracting evaluation system which simultaneously evaluates several inputs and outputs to the process (as opposed to single measures such as CALT), is a tool which is?				
102	A contracting evaluation system which compares all operational contracting squadrons while taking into account differences in squadron characteristics (such as manning, experience, and workload), is a tool which is?				
103	A contracting evaluation system which does not rely solely upon measures which the chain of command (LG, Wing CC) find important is a tool which is?				
104	A contracting evaluation system which compares squadrons relative to other contracting squadrons, is a tool which is?				
105	A contracting evaluation system which compares contracting squadrons to the best performers as opposed to the average, is a tool which is?				
106	A contracting evaluation system which provides managers with timely feedback, including exact data on resource utilization and relative efficiencies compared with other squadrons, is a tool which is?				

Once survey results were obtained, the data were analyzed using a methodology similar to that listed in Table 3.5. A Large Sample Test of Hypothesis About a Population Mean was used to determine the significance of the mean response for each of the eleven questions. Because the objective of this test was to examine both positive and negative responses, a two-tailed test was employed. The research was concerned with any significant differences above or below the neutral Likert scale response of 3.0. An example of this test is provided in Table 3.8.

TABLE 3.8 Large Sample Test of Hypothesis About μ

Two-Tailed Test $\alpha = .05$, $\alpha/2 = .025$

H_0: μ individual question = 3

H_a: μ individual question $\neq$ 3

Test Statistic: $z = \dfrac{\bar{X} - 3}{\sigma_{\bar{X}}}$

Where: $\sigma_{\bar{X}} = \sigma/\sqrt{n}$

Rejection Region: $z < -z_{\alpha/2}$
or $z > z_{\alpha/2}$

(37:357)

The decision to test mean responses away from the neutral response was made to ensure identification of any performance evaluation characteristic desired by managers. The purpose of the eleven questions was to discover opinions and feelings about current and desired methods to measure operational contracting performance. The goal was to ensure that relatively significant management desires were discussed in the results of the research.

Performance evaluation characteristics identified as important by managers were compared to the DEA results. This comparison was made by addressing the portions of DEA output which may aid operational contracting management to improve overall efficiency and performance. If the DEA model provided feedback and addressed the characteristics identified, it could be a useful addition to or replacement for current performance evaluation systems.

Chapter Summary

This chapter has provided an explanation of the research design and related DEA methodology. The chapter was divided in two parts. The first part introduced the primary DEA methodology. A complete list of DEA assumptions was initially provided to establish later model development. A simple graphical example using the same four hypothetical contracting squadrons, introduced in Chapter II, allowed development of the efficient frontier concept. The complete DEA linear programming model was then developed. This model allows for analysis of multiple inputs and multiple outputs for operational contracting squadrons.

Part II of the chapter provided the various methods employed to meet each research objective. Each of the five investigative questions, with specific analysis techniques, were addressed. The overall objective of developing an alternate method of measuring operational contracting performance will be achieved by answering each specific investigative question in Chapter IV.

IV. Results

Overview

The purpose of this chapter is to provide the results of the methodology employed to answer each of the investigative questions. The results are presented in a two-step fashion. Part I of this chapter provides the results to investigative questions one and two. Part I describes the selection of the most critical outputs and resources of an operational contracting squadron. The selection of resources and outputs was necessary to construct an appropriate DEA model and answer the remaining investigative questions.

Part II of this chapter answers investigative questions three through five. The major portion of these answers were discovered through an application of DEA to the DMUs selected from ACC and AFMC. After answering each of the investigative questions in Part I and Part II of this chapter, the primary objectives of this research were met. These objectives included developing a DEA model for operational contracting squadrons and evaluating DEA's output and potential use to managers for performance evaluation.

Part I: Selection of Critical Resources and Outputs

Before a DEA model for operational contracting squadrons could be constructed, critical resources and outputs to the contracting process were identified. These variables were later incorporated into the DEA model. This section of the chapter describes the management survey results and the selection of critical resources and outputs. This section provides answers to the first two investigative questions which are listed in Table 4.1.

TABLE 4.1 Investigative Questions 1 & 2

IQ 1:	What are the most critical outputs generated from the operational contracting function?
IQ 2:	What are the most critical resources available to operational contracting squadrons?

General Survey Results. The management survey, used to identify the variables to include in the DEA model, was sent to 258 possible respondents. Of these 258 surveys, 165 were returned. The overall return rate was 64%. Of the 165 returned surveys, only 153 were actually used in this study. Twelve surveys were determined unusable in this research. Each of the twelve unusable surveys were incomplete due to the respondent's lack of experience in operational contracting. The total usable return rate was 59%.

The first seven questions on the survey provided general demographic information. This information was not used in the actual DEA formulation, but it does provide information concerning the background of the managers responding. Table 4.2 provides demographic information gained from the survey.

TABLE 4.2 General Demographics

Average Contracting Experience	15.12
Average Experience in Current Position	2.98
Number of Officers Responding	51
Number of Civilians Responding	52
Number of Enlisted Responding	50
Percent in Same Job During Last IG	48.40
Number of Respondents from AMC	25
Number of Respondents from ACC	77
Number of Respondents from ATC	23
Number of Respondents from AFMC	13
Number of Respondents from Other Commands	15

Identification of Critical Resources and Outputs. The main purpose of the management survey was to identify those resources and outputs management deemed critical to the operational contracting process. These critical variables could then be included in a DEA model to measure a contracting squadron's productivity. The survey allowed contracting managers to rank each of the 51 possible variables, from definitely not important to definitely important, on a five point Likert scale. The numerical results were then used to identify those variables which were managerially significant.

In order to analyze the resources and outputs the mean response to each question was rank ordered. Results of this process are shown in Table 4.3.

TABLE 4.3 Mean Response to Possible Resources and Outputs

Question #	Description	Mean Response
56	Total Squadron Experience Level	4.59
25	Personnel Assigned vs. Authorized	4.52
15	Number of Contracts Behind Schedule	4.50
62	Total Number of Line Items Received	4.37
90	Total Number of Active Service Contracts	4.37
88	Total Number of Active Contracts	4.36
50	Number of Buyers/Contract Administrators	4.31
61	Total Number of Line Items Received Priority 1-8	4.31
89	Total Active Construction and Architect & Engineering Contracts	4.27
91	Total Number of Active Commodities Contracts	4.25
58	Total Experience Level Without Administrative or Clerical Support	4.20
51	Number of Clerical Personnel	4.18
26	Total Number of Contracting Actions	4.16
52	Number of Management Personnel	4.16
24	Percent Competitive Action Measure	4.14
53	Number of Assigned Civilians	4.14
65	Total Number of Modifications Executed	4.14
57	Average Office Experience Level	4.12
59	Average Office Experience Level Without Clerk or Administrative Support	4.11
55	Number of Assigned Enlisted Personnel	4.10
29	Total Dollars Awarded Competitively	4.10
63	Number of Different Customer Organizations Served	4.04
66	Priority 1 - 3 CALT	4.01
74	Total Number of Line Items Awarded	4.01
27	Total Number of Centralized Actions	4.01
75	Total Number of Centralized Line Items Awarded	3.98
87	Percent Competitive Dollars Awarded Measure	3.95
67	Priority 4 - 8 CALT	3.93
84	Total Number of Large Business Actions Available for Small Business	3.93
85	Total Large Business Dollars Awarded That Were Available for Small Business	3.87
69	Total Number of Decentralized Actions	3.87
68	Total Centralized Dollars Awarded	3.83
54	Total Dollars Awarded	3.81
73	Total Section 8A (Small Disadvantaged) Dollars Awarded	3.78
83	Total Set-Aside Actions	3.77
86	Small Business Dollars Awarded Divided by the Total Dollars Available for Small Business	3.77
28	Total Number of Decentralized Actions	3.77
77	Total Centralized Dollars Awarded	3.76
64	Total Dollars Awarded	3.76
72	Total Number of Section 8A (Small Disadvantaged) Actions	3.76
82	Total Modifications Divided by Centralized Actions Awarded	3.73
33	Number of Blanket Purchase Agreements Administered	3.64

TABLE 4.3 Continued

Question #	Description	Mean Response
76	Total Number of Decentralized Line Items Awarded	3.61
78	Total Decentralized Dollars Awarded	3.48
92	Priced Actions Divided by Unpriced Actions	3.42
79	Centralized Actions Divided by Centralized Line Items	3.41
12	Last Inspector General Rating	3.35
81	Decentralized Line Items Awarded Divided by Centralized Line Items Awarded	3.24
80	Decentralized Dollars Awarded Divided by Total Dollars Awarded	3.24
70	Total Number of Non-Appropriated Actions Awarded	2.96
71	Total Non-Appropriated Dollars Awarded	2.94

Rank ordering the possible resources and outputs by mean response provided a general indication of each variables importance to the operational contracting manager. However, a stronger statistical approach was needed in order to reduce the possible variables to those managers indicated as significant. A Large-Sample *Test of Hypothesis About a Population Mean* was conducted using the z statistic (37:356).

The mean response for all 51 questions was compared to the Likert scale response of 4.0. A response of 4.0 indicated a variable that was somewhat important to the contracting manager. A one-tailed test was employed in order to identify those variables whose mean response was significantly greater than the somewhat important survey response. The purpose of this comparison was to further reduce the number of critical resources and outputs based upon the management survey.

In order to provide an example of the application of a large sample test of hypothesis, the calculations for survey question 56 are provided in Table 4.4. This survey question covered the importance of total office experience level to the operational contracting manger. As the rank ordering of mean responses demonstrated, this question was ranked most important among those managers returning surveys.

TABLE 4.4 Hypothesis Test for Question 56

One-Tailed Test $\alpha = .05$

Ho: μ question 56 = 4

Ha: μ question 56 > 4

Test Statistic: $z = \dfrac{\bar{X} - 4}{\sigma_{\bar{X}}}$

Test Statistic: $z = \dfrac{4.595 - 4}{.057495}$

$z = 10.35$

Rejection Region: $z > z_{\alpha}$

$10.35 > 1.645$

Conclusion: Reject Null Hypothesis

The process of conducting large sample tests of hypothesis about a population mean was continued for all 51 possible resources and outputs. An α value of .05 was chosen to identify only those variables managerially important at the 95% significance level. This process reduced the number of variables to 16 possible resources and outputs to be included in the DEA model. A list of the variables considered for use in DEA, along with their test statistics and associated significance level is provided in Table 4.5.

TABLE 4.5 Variables Considered for DEA Use

Question #	Description	Test Stat	
56	Total Squadron Experience Level	10.35	*
25	Personnel Assigned vs. Authorized	8.20	*
15	Number of Contracts Behind Schedule	8.17	*
62	Total Number of Line Items Received	5.81	*
88	Total Number of Active Contracts	5.03	*
90	Total Number of Active Service Contracts	5.02	*
61	Total Number of Priority 1-8 Line Items Received	4.50	*
50	Number of Buyers/Contract Administrators	4.35	*
89	Total Number of Active Construction and Architect & Engineering Contracts	3.64	*
91	Total Number of Active Commodities Contracts	3.34	*
51	Number of Clerical Personnel	2.54	*
26	Total Number of Contracting Actions	2.48	*
52	Number of Management Personnel	2.15	*
24	Percent Competitive Action Measure	2.14	*
65	Total Number of Modifications Executed	2.07	*
29	Total Dollars Awarded Competitively	1.72	*
	* Significant at the 95% Level		

Testing the difference between means revealed 16 possible variables significant at the 95% level. All 16 variables were considered for use in the DEA model because operational contracting managers had identified them as significant resources and outputs to the operational contracting process. These variables also met several other characteristics outlined by Clarke and listed in Table 3.4. For example, the 16 possible variables are available to contracting managers. The variables, reported in ratio form, are separable into numerator and denominator values. All variables are numerical in nature. Finally, the 16 possible variables are readily understood by contracting management because they were chosen from the 7106 report.

Critical Variables Chosen for DEA Model. The 16 resources and outputs identified as significant by operational contracting managers also met the majority of Clarke's characteristics for inclusion into a DEA model. The final variable selection was made using two important criteria listed by Clarke. First, all data must be collected and reported in a consistent manner for all operational contracting squadrons. Second, all variables chosen must be managerially meaningful (14:377). This second criteria demanded that variables chosen must not only be rated as significant, but also have a strong impact on productivity and be controllable by management.

These final two criteria, along with the elimination of variables providing redundant information, allowed the 16 possible variables to be reduced to 9 outputs and resources to the contracting process. The following two sections describe each of the 9 variables chosen for the DEA model. These sections provide rationale for the use of these 9 variables.

IQ 1: Critical Outputs of the Contracting Process. Of the 9 variables included in the DEA model, five were outputs to the contracting process. The first of the five outputs was the number of active service contracts administered (SERVICE) by each contracting squadron. This output was measured using each squadron's 7106 report. The SERVICE variable measured the number of active service contracts on hand as of 30 September 1992. The contracting manager responses to the survey indicated this variable was significant at the 95% level.

The second output variable chosen was the number of active construction and architect and engineering contracts administered (CONST) by each contracting squadron. This data was also available on the 7106 report. The CONST variable measured the number of active construction and architect and engineering contracts on hand as of 30 September 1992. The contracting manager responses to the survey indicated this variable was significant at the 95% level.

The third output variable chosen was the number of active commodities contracts administered (COMOD) by each contracting squadron. Data for each squadron's active commodities contracts was available on their respective 7106 report. Contracting managers indicated this was significant at the 95% level. It is important to note that the COMOD variable, like SERVICE and CONST, is measured at a specific point and time. The current 7106 report does not provide a cumulative weighted average of active contracts throughout a fiscal year. All three variables were measured as of 30 September 1992.

The fourth output variable chosen was the total number of contracting actions executed (ACTION) by each squadron. This data was available on each squadron's 7106 report. The total actions figure used was the cumulative number of actions throughout fiscal year 1992. This includes centralized and decentralized actions performed by each contracting squadron. Decentralized actions are those contracting actions conducted by other members of the base population. For example, a hospital representative may have the authority (delegated by the contracting squadron) to make small dollar supply purchases without going through the contracting squadron. The contracting squadron retains administrative control and reporting responsibility for these decentralized actions. Once again, the ACTION variable was significant at the 95% level.

The fifth and final output used in the DEA model was the total dollars each squadron obligated using competitive procedures (COMP). Contracting managers ranked this and a variation of this variable, the percent competitive dollars measure, significant at the 95% level. The percent competitive dollars measure is difficult to separate into a numerator and denominator figure. Additionally, the chosen total competitive dollars obligated variable is more robust as it gives a better indication of the magnitude of competitive purchasing activity at each squadron. Finally, because it is a raw measure, not requiring separation into numerator and denominator, it is easier to interpret and more meaningful for contracting managers. Both variations of this same measure were considered significant by contracting managers. The COMP variable chosen for DEA provides more meaningful information than the percent competitive dollars measure omitted.

IQ 2: Critical Resources of Operational Contracting. After selecting five critical outputs, the DEA methodology mandated the selection of various critical inputs to the contracting process. A total of four inputs were chosen for this application of DEA. The first of these inputs was the total office experience level (EXP). Contracting managers selected this as the most critical resource to the operational contracting process. The EXP variable was determined significant at the 95% level. Each bases 7106 report contains a manpower data section. Each individual assigned to the squadron is listed in this section along with each individual's contracting experience.

The second input chosen for the DEA model was the number of buyers/administrators (BUYER) assigned to each squadron. This variable was determined significant at the 95% level. The manpower section of each 7106 report assigns a position title and Air Force Specialty Code (AFSC) to each individual in the squadron which denotes contracting responsibility. This information was used to identify those members of the squadron who were neither part of management or clerical and administrative support. The total number of buyers and/or contract administrators were then counted for each contracting squadron.

The third input chosen for the DEA model was the number of clerical or administrative support (CLERK) personnel assigned to each squadron. This was determined significant at the 95% level. The CLERK variable includes procurement clerks, secretaries, and squadron administrative support personnel. Once again, the data for individual squadrons was calculated from the manpower section of the 7106 report.

The fourth and final input chosen for the DEA model was the number of management personnel assigned (MGT) to each squadron. Survey results indicated this variable was significant at the 95% level. Data for this variable was also obtained from the manpower section of the 7106 report.

The process of reducing the number of input and output measures concentrated on providing contracting managers with meaningful feedback concerning squadron productivity and efficiency. Each of the 16 possible variables were managerially significant at the 95% level. The simple approach of choosing variables with the highest mean survey results would not have satisfied the objective of giving operational contracting managers meaningful feedback. For example, the input variables of BUYER, CLERK, and MGT were chosen because managers do have some control over the mix of personnel in the squadron. Because of the managerially meaningful objective, some variables with higher mean survey responses, and corresponding test statistics, were not chosen for inclusion in the DEA model.

Process Model for DEA. Before discussing the 12 significant variables not used in the DEA model, it is important to summarize the model chosen. A total of 9 variables were chosen using Clarke's characteristics listed in Table 3.4. Five of these variables were outputs and four were inputs to the contracting process. The operational contracting process modeled in this DEA application is shown in Figure 4.1.

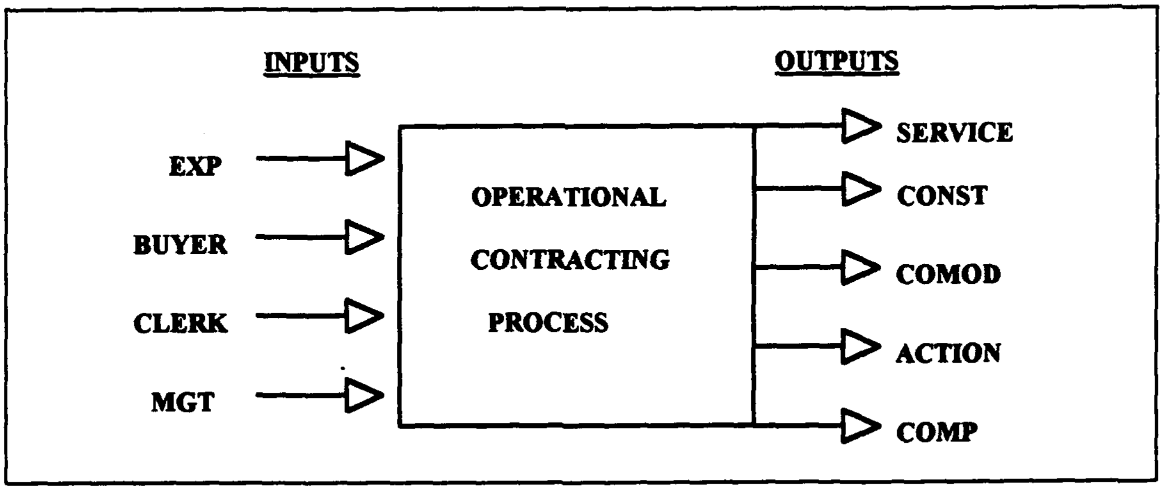

FIGURE 4.1 Operational Contracting DEA Model

Significant Variables Omitted from the DEA Model. After identifying those variables chosen for use in the DEA model, it is important to outline the rationale for not including the other seven variables. There were primarily three reasons for excluding certain variables. First, many of the variables provided information redundant with respect to measures chosen. Second, some variables did not justify inclusion into the DEA model because they failed to provide meaningful information which was also controllable by contracting managers. Finally, a few of the possible variables contained data measurement problems in the 7106 reports.

The first variable not used in the DEA model was the number of contracting personnel assigned versus the number authorized. Because the model includes all three categories of possible personnel as inputs (BUYER, CLERK, and MGT) the assigned versus authorized figure would have provided redundant information. Additionally, contracting managers have more control over the mix of human resources than the established squadron manning level.

The second variable not used in the DEA model was the number of contracts behind schedule. On the 7106 report, this measure is listed as the number of delinquent contracting actions. Although this measure is considered an excellent indication of the quality of service provided by a contracting squadron, the 7106 reports indicate a serious data measurement problem. Some squadrons had over 400 delinquent contracting actions, while other squadrons showed no delinquent contracting actions.

The third variable not included was the total number of line items received by each squadron. This variable is considered an input to the contracting squadron. In fact, a squadron's total workload is driven by the number of line items received from its customers throughout the fiscal year. However, contracting squadrons have no control over this variable. The number of line items received is driven by external factors such as budget levels and base needs. Because of this lack of control, this variable was considered less meaningful.

The fourth variable omitted from the DEA model was the total number of active contracts in each squadron. This output of the contracting process was determined significant by contracting managers. It is also a meaningful measure of the work generated by a squadron. However, three other variables were included in the DEA model which captured the information present in the total active contracts measure. These three variables were SERVICE, CONST, and COMOD.

The fifth variable not included in the DEA model was the number of priority 1-8 line items received by each contracting squadron. Priority 1-8 line items are those items which are higher priority requirements (as identified by the base customer) which limits the amount of time the contracting squadron has to make the purchase. Like the line items received measure, this variable was considered significant by contracting managers. Contracting squadrons may conduct customer education to train base personnel on the importance of keeping the priority rate at manageable levels. However, squadrons have no real control over the actual percentage of line items received which are priority purchase items. Because of this lack of control, this variable has less meaning than other inputs chosen for the DEA application.

The sixth variable omitted from the DEA model was the number of modifications executed by each squadron. This variable is a measure of the number of modifications or changes made to existing contracting instruments. This variable was rated significant by respondents. However, with the current 7106 report, it is impossible to distinguish between modifications executed because of contracting squadron error and modifications executed as a result of legitimate changes in customer requirements. If this distinction could be made in the future, this variable would be an excellent quality measure to include in a subsequent DEA model. Those modifications executed due to contracting squadron error could be included as a minimization variable. Modifications executed because of legitimate changes in customer requirements could be included as an output for DEA to maximize. This approach would increase the DEA rating when modifications are executed due to legitimate changes and decrease the DEA rating for modifications made because of contracting error. Because of the current measurement difficulty in this variable, it was not considered meaningful for inclusion in this DEA model.

The seventh variable not used in the DEA model was the percent competitive actions measure. This variable provides information concerning the percent of the squadron's total actions that were awarded using competitive purchasing procedures. The information provided by this measure was considered redundant with the total dollars awarded competitively (COMP) variable included in the DEA model. Both of these variables were rated as significant outputs by contracting managers. However, the COMP variable included was considered more robust because it also provides the magnitude of competitive purchasing conducted at each operational contracting squadron.

A total of seven managerially significant inputs and outputs to the contracting process were not included in this DEA model. The majority of the omitted variables contained redundant information when compared with those variables included in the model. However, the decision to omit certain variables does not mean they could not be included in a future DEA application. DEA is a flexible methodology which allows an unlimited combination of resources and outputs to measure operational contracting performance. The

DEA methodology can be repeated using a different combination of variables in order to examine productive efficiency with emphasis on different input and output variables.

Part I Summary. Part I of this chapter provided research results concerning investigative questions one and two. The use and analysis of the management survey identified the critical resources available to operational contracting managers. This same survey identified critical outputs to the operational contracting function. Each managerially significant variable was further examined using Clarke's five characteristics listed in Table 3.4. A total of 4 inputs and 5 outputs were chosen for the actual DEA application.

Part II: DEA Application and Results

After identifying the 9 variables for use in the DEA model, the methodology required the actual application of the DEA technique. This part of the chapter discusses these results and answers investigative questions three through five. Specifically, Part II of this chapter provides answers to the investigative questions listed in Table 4.6

TABLE 4.6 Investigative Questions 3-5

IQ 3:	What are the results of the application of the DEA technique to operational contracting performance measurement?
IQ 4:	What information does the DEA output provide the Air Force operational contracting manager?
IQ 5:	What characteristics of a performance measurement system are desired by operational contracting managers and how are they addressed by DEA?

DEA Validation and Data Used. Before the DEA process could be executed, two steps to ensure accuracy of results were completed. First, a test of an existing DEA problem was executed to ensure the accuracy of the methodology and the software used. Second, the archival data was collected from the BCAS 7106 reports for each base being analyzed. This collection resulted in the necessary elimination of seven bases from AFMC and a clarification of what was included in each of the nine variables.

The software used for the DEA application was Storm version 3.0. Storm is a commercially available quantitative modeling decision support software package. Storm has a standard linear programming module which was used in this DEA model. Before executing DEA for operational contracting squadrons, the methodology and tableau construction was validated using an existing data set with known results. The CCR (Charnes, Cooper, and Rhodes) ratio form of the DEA relative efficiency measure was replicated using data from an existing study by Clarke (14:377). By entering data from Clarke's study into Storm 3.0, the DEA results were replicated exactly.

After completion of the methodology validation, data for the 9 input and output variables was collected from the 7106 reports. This data covered fiscal year 1992 which began on 1 October 1991 and ended on 30 September 1992. A complete listing of the input and output data for the operational contracting squadrons used in the DEA is provided in Table 4.7.

TABLE 4.7 DEA Input and Output Data

	OUTPUTS					INPUTS			
	SERVICE	CONST	COMOD	ACTION	COMP	EXP	BUYER	CLERK	MGT
ACC Bases									
Carswell	40	11	4	17648	21031094	216.92	17	3	5
Bergstrom	79	30	16	47599	13554752	162.39	14	1	6
Dyess	51	47	6	17893	30074912	205.38	22	3	7
Ellsworth	95	69	13	35141	37544932	321.38	27	3	9
F.E. Warren	50	51	9	24266	19826151	273.52	23	1	7
George	26	6	2	11087	11999228	77.88	5	1	3
Cannon	29	90	6	26916	20708286	264.45	32	3	8
Shaw	149	64	26	23104	34184793	408.13	35	3	7
Holloman	55	78	70	38666	58702180	472.75	37	4	9
Langley(base)	47	96	34	32033	59407071	411.44	53	8	8
McConnell	25	37	8	20519	19166577	199.40	17	2	7
Offut (3908th)	88	13	33	1979	77837439	329.00	25	5	9
Homestead	103	121	14	24951	19862203	285.63	30	3	8
MacDill	78	118	66	92658	44333345	465.50	47	4	8
KI Sawyer	34	82	8	.17062	16966961	243.38	19	2	8
Grand Forks	57	65	6	50928	36298917	247.14	30	3	8
Loring	35	28	4	17322	12051656	179.13	16	2	7
Moody	72	112	13	19517	17416578	295.18	25	2	7
Offut (55 Cons)	145	100	26	47650	60214506	347.39	44	6	8
Pope	43	47	9	12760	17110521	250.12	25	3	5
Nellis	102	66	13	36381	73844156	522.27	49	9	7
Myrtle Beach	20	5	1	7618	5602865	140.92	8	1	4

Table 4.7 Continued

	OUTPUTS				INPUTS				
	SERVICE	CONST	COMOD	ACTION	COMP	EXP	BUYER	CLERK	MGT
Mountain Home	39	49	18	24680	29807899	280.95	27	3	7
Eaker	13	6	1	12276	2844394	77.92	6	1	3
Barksdale	61	49	10	39892	26449439	294.27	23	4	7
Beale	30	66	6	26472	24487624	195.18	15	4	7
Castle	47	12	5	22075	14665634	241.32	16	3	6
Fairchild	35	40	3	34055	19202276	259.39	29	2	7
Davis-Monthan	67	67	15	66608	34799160	378.88	34	4	8
Griffiss	108	93	62	43087	42845731	419.07	37	3	7
Minot	66	86	9	33962	29354337	202.38	25	3	6
Luke	159	210	72	25138	38278784	350.30	35	5	8
Seymour-Johnson	40	70	21	24014	24447210	204.07	22	4	7
Langley (Central)	71	0	52	1875	204281786	378.23	29	6	9
Tyndall	140	38	39	45160	47922318	402.16	40	9	6
Wurtsmith	33	10	2	9486	9440330	122.97	10	3	3
Whiteman	49	29	13	27753	24339193	274.69	24	3	7
Howard	37	61	42	22134	15971778	157.68	15	3	7
Riyad	8	9	8	2644	18178744	57.00	3	3	4
AFMC Bases									
Newark	26	33	52	7921	17391753	233.23	24	5	5
Brooks	117	55	70	14441	45811728	256.48	28	1	7
Kelly	111	98	89	33277	101470275	717.08	60	14	7
Robbins	97	115	96	31399	102991821	894.35	54	25	8
Hanscom	156	170	86	32332	93872860	506.82	27	5	7
Kirtland	79	84	31	24199	62019532	472.76	39	4	6

In order to allow for replication of this research, clarification of the operational contracting squadrons rated and variables used is required. The two commands used for the DEA were ACC and AFMC. If all squadrons in these commands were used, a total of 52 DMUs would be rated by DEA. However, while collecting the actual input and output measures from the 7106 reports, seven contracting squadrons from AFMC were removed from the DMU listing. The seven squadrons not used included: Eglin AFB, Wright-Patterson AFB, Tinker AFB, Edwards AFB, SMC/PKD, McClellan AFB, and Hill AFB. These squadrons were removed because information in the manpower section of the 7106 report was incomplete. After removal of these squadrons, the DEA was performed on the remaining 45 operational contracting squadrons.

The five output variables used in the DEA model were SERVICE, CONST, COMOD, ACTIONS, and COMP. The SERVICE and COMOD variables measured the number of active service and commodities contracts at each squadron as of 30 September 1992. The CONST variable measured the active construction and architect and engineering contracts at each squadron as of 30 September 1992. The ACTION variable measured the cumulative number of contracting actions executed by each contracting squadron throughout fiscal year 1992. Finally, the COMP variable measured the cumulative dollars spent using competitive procedures throughout fiscal year 1992.

The four input or resource variables included EXP, BUYER, CLERK, and MGT. The EXP variable measured the total office experience level, in years, for each contracting squadron. This included all personnel regardless of position within the squadron.

The BUYER variable provides a count of the number of buyers or contract administrators at each squadron. Although Copper Cap and Palace Acquire personnel were often assigned to the management section of the 7106 report, they were counted in the BUYER variable for the purposes of this study. The CLERK variable provides a count of the number of procurement clerks, secretaries, and administrative support personnel assigned to each squadron.

Finally, the MGT variable provides a count of the management in contracting squadron. For the purposes of this study, personnel assigned to management (front office), and flight chiefs were included in the MGT variable. Administrative support and secretarial personnel assigned to the front office were not counted in the MGT variable, but were included in the CLERK variable. Contract Management Officers or Officer Trainees were counted as management if they were listed in the management section of the 7106 report. If they were assigned to a flight, other than as a flight chief, they were counted as part of the BUYER variable.

IQ 3: DEA Application and Results. The DEA application consisted of a linear program for each operational contracting squadron or DMU under analysis. DEA revealed 15 DMUs which were rated one hundred percent efficient. These DMUs received a DEA rating of 1.0. Each contracting squadron, its DEA rating, and the efficiency reference set (ERS) for those squadrons with a rating less than 1.0 is provided in Table 4.8.

TABLE 4.8 DEA Ratings and Efficiency Reference Sets

Base	DEA Rating	Efficiency Reference Set
Carswell	0.541183	Bergstrom , MacDill, Offut(55), Langley(Central), Hanscom
Bergstrom	1.0	
Dyess	0.687098	Bergstrom, Minot, Luke, Langley(Central)
Ellsworth	0.732404	Bergstrom , Luke, Langley(Central), Brooks, Hanscom
*F.E. Warren	1.0	
George	0.969633	Bergstrom, Langley (Central), Riyad, Hanscom
Cannon	0.744715	Bergstrom, Luke, Langley (Central), Brooks
Shaw	1.0	
Holloman	0.796676	Bergstrom, MacDill, Howard, Brooks, Hanscom
Langley (base)	0.736773	MacDill, Luke, Langley (Central), Hanscom
McConnell	0.615908	Bergstrom, Luke, Langley (Central), Brooks, Hanscom
Offut (3908th)	0.812527	Bergstrom, Langley (Central), Hanscom
Homestead	0.908895	Bergstrom, Moody, Luke, Brooks
MacDill	1.0	
KI Sawyer	0.881624	Bergstrom, Moody, Luke, Hanscom
Grand Forks	0.970528	Bergstrom, MacDill, Minot, Langley (Central)
Loring	0.506237	Bergstrom , Luke, Langley (Central), Riyad
Moody	1.0	
Offut (55 Cons)	1.0	
Pope	0.475832	Bergstrom, MacDill, Offut (55), Luke, Langley (Central), Hanscom
Nellis	0.865611	MacDill, Langley (Central), Tyndall, Kelly, Hanscom
Myrtle Beach	0.436173	Bergstrom, Hanscom
Mountain Home	0.598672	Bergstrom, Minot, Luke, Langley (Central), Hanscom
Eaker	0.601126	Bergstrom
Barksdale	0.721369	Bergstrom, MacDill, Langley (Central), Hanscom
Beale	0.953792	Bergstrom, Luke, Riyad, Hanscom
Castle	0.516291	Bergstrom, Hanscom
Fairchild	0.632541	Bergstrom, MacDill, Luke, Langley (Central), Hanscom
Davis-Monthan	0.876473	Bergstrom, MacDill, Langley (Central)
Griffiss	0.953171	Bergstrom, MacDill, Brooks, Hanscom
Minot	1.0	
Luke	1.0	
Seymour-Johnson	0.821353	Bergstrom, Minot, Luke, Langley (Central)
Langley (Central)	1.0	
Tyndall	1.0	
Wurtsmith	0.640261	Bergstrom, Luke, Hanscom
Whiteman	0.539581	Bergstrom, MacDill. Offut (55), Langley (Central). Tyndall, Hanscom
Howard	1.0	
Riyad	1.0	
Newark	0.947419	Brooks, Hanscom
Brooks	1.0	
Kelly	1.0	
Robbins	0.951574	Kelly, Hanscom

TABLE 4.8 Continued

Base	DEA Rating	Efficiency Reference Set
Hanscom	1.0	
Kirtland	0.768904	Langley (Central), MacDill, Hanscom

* Unenveloped Solution

The results indicate a large range of relative efficiency scores for each of the squadrons not receiving a rating of 1.0. These scores ranged from a low of .436173 at Myrtle Beach AFB to a high of .970528 at Grand Forks AFB. In other words, Myrtle Beach AFB is 43.6% efficient and Grand Forks AFB is 97.1% efficient relative to the other DMUs.

After examination of the general results, a discussion of the 15 squadrons receiving a DEA rating of 1.0 is required. In order to ensure each of these squadrons is receiving a true relative efficiency score of 100%, the possibility of an unenveloped solution (as discussed in Chapter III) must be considered. If one of the DMUs receives a DEA rating of 1.0 resulting from an unenveloped solution, the DMU could use fewer inputs to generate the same level of output. This possibility was checked by examining the Efficiency Reference Set (ERS) of inefficient DMUs. Table 4.9 lists all squadrons receiving a score of 1.0 and the number of times the squadron appeared in the ERS of an inefficient DMU.

TABLE 4.9 DMUs With Efficiency Score of 1.0

DMU	Number of Listings in Another DMUs Efficiency Reference Set (ERS)
Bergstrom	25
* F.E. Warren	0
Shaw	0
MacDill	12
Moody	2
Offut (55Cons)	3
Minot	4
Luke	14
Langley (Central)	19
Tyndall	2
Howard	1
Riyad	3
Brooks	7
Kelly	2
Hanscom	22

*** Unenveloped Solution**

The results show that 13 of the 15 squadrons receiving a DEA rating of 1.0 appear in the ERS of other inefficient squadrons. F.E. Warren AFB and Shaw AFB fail to appear in an inefficient DMU's ERS and therefore have the possibility of being unenveloped. Both squadrons could have a non-zero slack variable assigned to one or more of the inputs indicating the DMU could have produced the same level of output with less of one or more inputs.

An examination of the DEA solution for Shaw AFB showed no non-zero slack values associated with the inputs. This indicates Shaw AFB is not an unenveloped solution and is considered efficient. The DEA solution for F.E. Warren AFB revealed non-zero slack values for the inputs EXP and BUYER.

This indicates F.E. Warren AFB received a DEA rating of 1.0 as the result of an unenveloped solution. F.E. Warren could have produced the same level of output with lower levels of office experience and fewer buyers and/or contract administrators. Therefore, F.E. Warren AFB should not be considered truly efficient. As a result of this unenveloped solution, the number of relative efficient contracting squadrons is reduced to 14 out of 45 examined.

IQ 4: Information Provided to Operational Contracting Managers from DEA. The performance measurement and evaluation feedback is not limited to the DEA rating and identification of the ERS for each relatively inefficient DMU. DEA provides a wealth of information to help managers improve performance relative to their peers. After giving managers a ranking of their overall relative efficiency, improvement information can be gained from the weights assigned to the inputs and outputs in the DEA solution.

DEA allows input and output weights to vary depending on the characteristics of each operational contracting squadron. Specifically, the DEA methodology allows the assigned input and output weights to vary depending on their relative importance to each individual squadron. In this way, each DMU is evaluated according to the inputs and outputs it combines in the most efficient manner. The DEA weights assigned to each contracting squadron's inputs and outputs are shown in Table 4.10.

TABLE 4.10 DEA Input and Output Weights

BASE	EXP	BUYER	CLERK	MGT	SERVICE	CONST	COMOD	ACTION	COMP
Carswell	0.00157	0.00217	0	0.1245	0.00408	0	0	0.00001	7.16E-09
Bergstrom	0.00616	0	0	0	0	0.00481	0	0.00001	1.13E-08
Dyess	0.00487	0	0	0	0.00278	0.00367	0	0.0000074	7.98E-09
Ellsworth	0.00175	0.00233	0.1254	0	0	0.00444	0	0.00000442	7.2E-09
F.E. Warren	0	0	1	0	0	0.0128	0	0.00001	2.65E-09
George	0	0.1978	0.0112	0	0.0143	0	0	0.00003	2.41E-08
Cannon	0.00225	0	0.1347	0	0	0.00488	0	0.00000514	8.08E-09
Shaw	0.00171	0	0	0.0567	0.00648	0	0	0	0
Holloman	0.00094	0.0092	0.0108	0.0191	0	0	0.00734	0.0000058	0
Langley (base)	0.00157	0	0	0.0444	0	0.00272	0	0.00000595	4.8E-09
McConnell	0.00273	0.00364	0.1964	0	0	0.00696	0	0.00000693	1.13E-08
Offut (3908th)	0.00135	0.0222	0	0	0.00611	0	0	0	3.53E-09
Homestead	0.00129	0	0.2102	0	0.00118	0.00573	0	0.00000297	0
MacDill	0	0	0.1667	0.0416	0	0.00116	0	0.00000612	6.68E-09
KI Sawyer	0	0.0295	0.2199	0	0	0.00904	0	0.00000721	0
Grand Forks	0.00283	0	0	0.0376	0	0.00272	0	0.00001	6.8E-09
Loring	0.00335	0.025	0	0	0	0.00657	0	0.00001	9.64E-09
Moody	0.00084	0	0.2342	0.0404	0	0.00739	0	0.00000794	0
Offut (55Cons)	0.00148	0	0	0.0607	0.00575	0	0	0.0000031	0
Pope	0.00258	0	0.0152	0.0618	0.00173	0.00319	0	0.00000996	7.25E-09
Nellis	0.00015	0	0	0.1373	0.00132	0	0	0.0000086	5.66E-09
Myrtle Beach	0	0.1191	0.0476	0	0.0215	0	0	0	0
Mountain Home	0.00201	0	0.0854	0.0254	0	0.00418	0	0.00000716	7.29E-09
Eaker	0	0.1667	0	0	0	0	0	0.00005	0
Barksdale	0	0.0208	0	0.0747	0	0.00043	0	0.00001	6.1E-09
Beale	0.00347	0.0215	0	0	0	0.00623	0	0.00001	9.67E-09
Castle	0	0.0625	0	0	0.00985	0	0	0.00000174	0
Fairchild	0.00231	0	0.0962	0.0297	0	0.00477	0	0.00000827	8.34E-09
Davis-Monthan	0	0.0154	0	0.0596	0	0	0	0.00001	4.7E-09
Griffiss	0	0	0.0938	0.1027	0.00398	0	0.00284	0.00000706	0
Minot	0.00343	0	0.0118	0.0452	0	0.0059	0	0.00001	0
Luke	0.00111	0	0.1057	0.0105	0	0.00374	0	0	5.62E-09
Seymour-Johnson	0.0049	0	0	0	0	0.00423	0.00351	0.00001	8.08E-09
Langley (Central)	0	0	0.00016	0.111	0.00087	0	0	0.00000669	4.53E-09
Tyndall	0	0.00924	0	0.105	0.00375	0	0	0.00000944	0

TABLE 4.10 Continued

BASE	EXP	BUYER	CLERK	MGT	SERVICE	CONST	COMOD	ACTION	COMP
Wurtsmith	0.00267	0.0421	0	0.0832	0.0191	0	0	0	0
Whiteman	0.00124	0.0016	0	0.0888	0.00289	0.00021	0	0.00000945	5.34E-09
Howard	0.00634	0	0	0	0	0.00471	0.0166	0	0
Riyad	0	0.3333	0	0	0	0.0155	0	0	4.73E-08
Newark	0.00146	0	0	0.1319	0	0	0.0179	0	0
Brooks	0.00219	0	0	0.0628	0.00241	0	0.00568	0.0000082	4.45E-09
Kelly	0.00018	0	0	0.1249	0	0	0.00806	0.00000544	0
Robbins	0	0.00103	0	0.118	0	0	0.00884	0	0
Hanscom	0.00165	0	0	0.0237	0	0.00085	0.00485	0.0000058	2.84E-09
Kirtland	0	0	0	0.1667	0	0.00103	0	0.00000961	7.25E-09

Note: A weight of 0 is equivalent to 1.0E-09.

The weights assigned to each input and output variable allow the contracting manager to examine possible improvements. Each weight is analogous to marginal productivity in economic theory. For example, the weight assigned the BUYER variable at Wurtsmith AFB is .0421. This means for every unit decrease in the number of buyers, Wurtsmith AFB can expect a 4.2% increase in their relative efficiency score.

Following the same logic, every unit increase in an output will result in a efficiency score increase equal to the corresponding output weight. Again using Wurtsmith AFB as an example, each additional active service contract will produce a 1.9% increase in the DEA rating. This improvement analysis is valid as long as any output increase or input decrease does not force the relative efficiency above 100%. Should this occur, the DEA model must be rerun and the results reexamined.

The information provided by the DEA results does not stop with input and output weights. DEA provides the operational contracting manager with information on how to improve the overall relative efficiency score. This can be accomplished by examining the DEA generated Efficiency Reference Set (ERS) and Hypothetical Comparison Unit (HCU). Those squadrons receiving a DEA rating less than 1.0 have a corresponding ERS and HCU. This comparison allows managers to identify which inputs and outputs can be changed in order to improve performance. The comparison also provides critical information about how much each input and output variable must be changed in order to achieve relative efficiency. An example of ERS analysis for Wurtsmith AFB is provided in Table 4.11. Recall that Table 4.8 provided the ERS for each of the inefficient DMUs including Wurtsmith AFB.

TABLE 4.11 Wurtsmith AFB Compared With its ERS

Outputs & Inputs	Wurtsmith Actual Inputs & Outputs	Derived Composite ERS (Bergstrom, Luke, & Langley (Sys) AFBs	Excess Inputs of Wurtsmith AFB vs. Bergstrom, Luke, & Langley(Sys) AFBs
SERVICE	33	33	0
CONST	10	10	0
COMOD	2	2	0
ACTION	9486	9486	0
COMP	9440330	9440330	0
EXP	122.97	78.87	44.1
BUYER	10	6.41	3.59
CLERK	3	.821	2.179
MGT	3	1.922	1.078

The information to complete this ERS analysis is included in the DEA output. The HCU is merely a linear combination of the input and output vectors of those DMUs listed in the ERS of a relatively inefficient DMU. Once the HCU is determined, the amount of excess inputs used to produce the level of output is calculated. By using this information, the operational contracting manager can decide which variables to reduce and the amount of reduction required. Holding output levels constant, Wurtsmith AFB would have to reduce its inputs by the amount indicated in order to become relatively efficient. Management judgment is required when interpreting these results. For example, it is impossible to reduce the number of buyers and/or contract administrators by exactly 3.59.

In order to compare each DMU with its ERS, a single HCU must be derived for each relatively inefficient DMU. Fortunately, the DEA output provides all the information to complete these calculations. As previously stated, the HCU is a linear combination of the input and output vectors for each DMU listed in an ERS. The DEA output provides the dual variable (shadow price) for each DMU in the ERS. This dual variable is the multiplier used to compute the HCU. An example calculation of the HCU is provided in Table 4.12.

TABLE 4.12 Derivations of HCU Values For Wurtsmith AFB

Outputs & Inputs	Dual VAR For Bergstrom AFB From DEA	Output & Input Vector for Bergstrom AFB	Dual VAR for Luke AFB From DEA	Output & Input Vector For Luke AFB
SERVICE		79		159
CONST		30		210
COMOD		16		72
ACTION		47599		25138
COMP		13554752		38278784
	.1493		.0864	
EXP		162.98		350.8
BUYER		14		35
CLERK		1		5
MGT		6		8

Outputs & Inputs	Dual VAR for Hanscom From DEA	Output & Input Vector for Langley (Sys)	Composite ERS (HCU)
SERVICE		156	33
CONST		170	30.77
COMOD		86	12.73
ACTION		32332	10857.15
COMP		93872860	9827521.4
	.0479		
EXP		506.82	78.87
BUYER		27	6.41
CLERK		5	.821
MGT		7	1.922

The initial DEA results demonstrated the ERS for Wurtsmith AFB contained Bergstrom AFB, Luke AFB, and Hanscom AFB. These DMUs are used to derive Wurtsmith's HCU. Once derived, the HCU input levels are compared to the actual input levels of the relatively inefficient DMU. This analysis was shown in Table 4.11 when Wurtsmith AFB was compared to its ERS. The HCU derivations for the remaining relatively inefficient operational contracting squadrons are provided in Appendix D.

The DEA results provide operational contracting managers with additional information to aid performance improvement. DEA assumes that any point along the efficient frontier is obtainable. Because of this, an inefficient DMU is not limited to improvements based solely on the ERS and HCU analysis. Managers may decide it is not possible to reduce inputs in the same proportions as specified by their HCU. A possible path to a DEA rating of 1.0 is to multiply each of the input levels by the efficiency rating obtained from the DEA results. For example, Wurtsmith AFB could multiply each of its current inputs by .640261 to obtain a rating of 1.0.

An inefficient DMU can also determine the reduction in a single input required to obtain an efficiency score of 1.0. A simple formula to use in this calculation, along with an example from Wurtsmith AFB is provided in Table 4.13.

TABLE 4.13 Single Input Reduction Calculation

$$\frac{1 - \text{Efficiency Rating}}{\text{DEA Weight on Decision Input Variable}}$$

BUYER Variable at Wurtsmith AFB : $\dfrac{1 - .640261}{.0421} = 8.54$

This calculation demonstrates that if Wurtsmith AFB reduced its number of buyers or contract administrators by 8.5, they would immediately become relatively efficient. This improvement holds true as long as other input and output variables remain constant. Once again, management judgment is required when interpreting this result. Because Wurtsmith had 10 buyers and/or contract administrators at the time of this study, it may be unwise to remove 8 or 9 personnel from the buyer variable.

The DEA solution provides operational contracting managers with a wealth of information concerning relative efficiency. The DEA technique provides feedback on squadron productivity and allows the evaluation of alternate methods of performance. After examining the DEA results, the contracting manager can decide on which inputs and outputs to change. These changes are made with full knowledge of target input and output levels which would make the squadron relatively efficient.

<u>IQ 5: What Characteristics of a Performance Measurement System are Desired by Operational Contracting Managers and How are They Addressed by DEA</u>? After uncovering critical input and output variables, constructing and executing the DEA model, and providing a summary of DEA information, the research turned to uncovering desired characteristics of a performance measurement system. On the same survey used for input and output identification, operational contracting managers were asked eleven questions concerning performance measurement, evaluation, and feedback. These questions addressed current methods of evaluation and characteristics of a desired system.

After collecting the survey results, a large sample test of hypothesis was conducted to uncover responses that differed from the neutral Likert scale value of 3.0 (37:356). The purpose of this test was to uncover operational contracting management's views about current methods of evaluation, feedback, and desired evaluation system characteristics. A mean response which varied significantly from the neutral Likert response of 3.0 warranted further investigation. Table 4.14 provides the survey question, mean response, test statistic (z value), and significance levels for each of these questions.

TABLE 4.14 Survey Questions Responding to IQ 5

Strongly Agree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

#	Question	Mean	Test Stat	
8	The current Command IG evaluation system satisfactorily measures organizational performance.	2.92	-1.07	
9	An evaluation system, different from the Command IG, would be useful in measuring overall organizational performance.	3.6	8.38	*

Definitely Not Important	Somewhat Not Important	Neutral	Somewhat Important	Definitely Important
1	2	3	4	5

#	Question	Mean	Test Stat	
98	The current IG method of performance evaluation provides feedback to help improve performance which is?	3.63	7.57	
99	Current Command and Air Force awards provide feedback concerning performance which is?	3.24	1.93	
100	Improving operational contracting squadron productivity and efficiency is a goal which is?	4.84	45.46	*
101	A contracting evaluation system which simultaneously evaluates several inputs and outputs to the process (as opposed to single measures such as CALT), is a tool which is?	4.497	25.80	*
102	A contracting evaluation system which compares all operational contracting squadrons while taking into account differences in squadron characteristics (such as manning, experience, and workload), is a tool which is?	4.14	12.35	*
103	A contracting evaluation system which does not rely solely upon measures which the chain of command (LG, Wing CC) find important is a tool which is?	4.01	11.39	*
104	A contracting evaluation system which compares squadrons relative to other contracting squadrons, is a tool which is?	3.24	2.37	*
105	A contracting evaluation system which compares contracting squadrons to the best performers as opposed to the average, is a tool which is?	3.08	0.81	
106	A contracting evaluation system which provides managers with timely feedback, including exact data on resource utilization and relative efficiencies compared with other squadrons, is a tool which is?	4.0	10.73	*

(*) Significant at the 95% level

The results for the questions covering current methods of performance evaluation (questions 8, 9, 98, and 99) demonstrate responses that may indicate a need for an alternate evaluation system. Managers did not disagree that the current Command IG evaluation system satisfactorily measures performance. However, when asked about the usefulness of an evaluation system other than the Command IG, managers responded significantly above the neutral response. When asked about the feedback provided by the current IG method of evaluation, managers responded significantly above the neutral response. Finally, managers were asked about the importance of the feedback provided by Air Force and Command awards. The results of this question did not differ from the neutral response.

The analysis of the questions concerning current methods of operational contracting evaluation did not provide conclusive results. Contracting managers did not provide a significant indication that they were completely disenchanted with performance evaluation techniques in place. However, responses to the remaining survey questions did show managers desired characteristics that are not present in current methods of performance evaluation.

When asked about the importance of improving operational contracting productivity and efficiency (question 100), contracting managers responded with a mean of 4.84. The test of hypothesis indicated this mean was different from the neutral response of 3.0 at the 95% significance level. Because DEA addresses each DMUs relative efficiency or productivity, it may be well suited to aid contracting managers in achieving gains in this area. As demonstrated in IQ 4, DEA provides a relative efficiency score for each squadron as well as which inputs and outputs to change for improvement.

The response to the importance of an evaluation system that considers several inputs and outputs to the process (question 101), provided a mean of 4.497. This mean was found to be significantly different from a neutral response at the 95% level. These results indicate contracting managers desire an evaluation system which can provide aggregate analysis of inputs and outputs. DEA appears to be well-suited to meet this desire. The model constructed for this study utilized 4 inputs and 5 outputs while providing a single measure of performance.

The next two questions covered manager's opinion about an evaluation system which takes into account differing squadron characteristics (question 102) and a system which does not rely solely on measures which the local base chain of command find important (question 103). The operational contracting manager's responses to questions 102 and 103 revealed mean responses of 4.14 and 4.013 respectively. Both of these means differed from the neutral (3.0) response at the 95% significance level.

Contracting managers revealed they would be interested in an evaluation system which takes into account differences in missions, goals, characteristics, and other squadron specific factors. DEA can handle this desire through flexible weighting of the input and output variables chosen. DEA attempts to maximize the efficiency score for each squadron, thus each squadron is evaluated on what it does best. In this manner, DEA can evaluate relative efficiency between squadrons with differing characteristics.

Additionally, contracting managers do not like the traditional use of single performance measures. Survey results indicated this may be especially true when the base or wing chain of command concentrates on specific items such as CALT. Once again, DEA appears to be an improvement over this current concentration on single measure performance evaluation. Quite simply, DEA can handle evaluation of several input and output factors at one time.

When asked about an evaluation system which compares squadrons relative to other squadrons, managers provided a mean response of 3.24. This was significantly different from the neutral response at the 95% level. This result indicates contracting managers are interested in a system which compares relative performance between squadrons. As demonstrated, DEA calculates efficiency based upon relative comparison between DMUs. In this manner, squadrons are compared to their peers instead of an arbitrary standard.

Question 105 did not result in a mean response significantly different from the neutral response. This question asked managers about the importance of comparing squadrons to the best performers instead of a measure of average performers. It appears contracting managers are neutral about the idea of being compared against the best squadrons in the Air Force.

Finally, when asked about the importance of an evaluation system providing timely feedback on resource utilization and relative efficiency (question 106), managers responded with a mean of 4.0. This response was significantly different from the neutral response at the 95% level. The DEA technique is well-suited to provide resource utilization and relative efficiency feedback. DEA output includes the weights assigned to decision variables, along with the ability to examine the operations of the HCU.

In summary, the results generated for IQ 5 indicate operational contracting do have some specific desired characteristics of a performance measurement and evaluation system. These characteristics appear to be well-suited to the characteristics of the DEA methodology. Specifically, managers want to improve productivity and efficiency. They think an evaluation system that examines several inputs and outputs simultaneously is important. Managers would like to see a system which takes into account different squadron characteristics. Contracting managers also believe too much emphasis is placed on single performance indexes. Finally, managers desire a system which provides timely feedback concerning resource utilization and efficiency.

As discussed, the DEA technique appears to satisfy the most significant concerns of operational contracting managers. Its ability to allow flexible weighting and evaluate several inputs and outputs simultaneously addresses the significant characteristics identified by managers. Although contracting managers may not want to remove current methods of performance measurement, the characteristics and feedback potential of DEA make it a viable addition to current methods.

Part II Summary. This part of the chapter provided answers to investigative questions three through five. The DEA model was constructed and applied to 45 operational contracting squadrons in ACC and AFMC. The results showed 15 squadrons which received an efficiency score of 1.0. One of these squadrons was unenveloped and was not considered relatively efficient. All information provided by DEA output was reviewed. Example ERS and HCU calculations were demonstrated using Wurtsmith AFB. Finally, the management survey provided desired characteristics of an operational contracting performance evaluation system. The survey responses were analyzed and desired characteristics compared to the output provided managers through DEA application.

Chapter Summary

The application of the DEA methodology provided interesting results. The results were divided in two parts. Part I of this chapter explained the selection of outputs and resources for use in the DEA model. Part II provided results for the application of DEA to 45 operational contracting squadrons in ACC and AFMC.

The answers to investigative questions one and two were discovered by analyzing the management survey to identify critical outputs and inputs to the contracting process. The Large Sample Test of Hypothesis revealed 16 possible input and output variables significant at the 95% level. They were reduced to five outputs and four inputs to include in the DEA model. The outputs used were the number of active service contracts, the number of active construction contracts, the number of active commodities contracts, the total number of contracting actions, and the total dollars awarded using competitive procedures. The inputs included the total office experience level, the number of buyers, the number of clerks, and the number of management at each contracting squadron.

Investigative question three was answered by building and executing the DEA model for the 45 operational contracting squadrons under study. The DEA consisted of a linear program for each contracting squadron. The results of DEA identified 15 squadrons with a relatively efficient score of 1.0. Further analysis demonstrated F.E. Warren AFB was an unenveloped solution and could have produced the same level of output with fewer inputs.

The DEA results demonstrated a large range of relative efficiency scores for squadrons not receiving a rating of 1.0. These scores ranged from a low of .436173 at Myrtle Beach AFB to a high of .970528 at Grand Forks AFB. In DEA terminology, Myrtle Beach is said to be 43.6% efficient and Grand Forks is 97.1% efficient relative to the other operational contracting squadrons.

In addition to the DEA ratings, the answer to investigative question three provided an efficiency reference set (ERS) for each of the squadrons not receiving a DEA rating of 1.0. The ERS provides the contracting manager with a group of efficient squadrons to emulate for future performance improvement. The squadrons listed in the ERS combine inputs to create outputs in a similar fashion as the inefficient squadron. In other words, the squadrons in the ERS use production technology similar to the inefficient squadron.

The answer to investigative question four detailed the performance improvement information provided the operational contracting manager from the DEA output. This information was contained in four parts of the DEA results. First, the DEA output includes decision variable weights which are analogous to marginal productivity in economic theory.

Second, DEA output allows the contracting manager to examine the excess inputs used in the contracting process. By reducing the excess inputs and holding the output level constant, a contracting squadron can improve performance and receive a DEA rating of 1.0. Third, the DEA output provides a dual solution (shadow price) for each squadron appearing in the ERS of an inefficient squadron. This dual solution is the multiplier used to calculate the Hypothetical Comparison Unit (HCU). Once calculated, the HCU provides the contracting manager with exact quantities of inputs and outputs to target for performance improvement. Finally, DEA output provides a single input reduction calculation for performance improvement. This calculation gives the reduction needed in one input in order to reach the efficient frontier and receive a DEA rating of 1.0.

Investigative question five was concerned with contracting manager perceptions about current methods and desired characteristics of performance measurement and evaluation. Eleven questions on the management survey were analyzed using a Large Sample Test of Hypothesis. The results of this analysis indicated that DEA is a useful addition to operational contracting performance evaluation. Specifically, managers expressed a need for improving productivity and efficiency. The DEA technique is designed to measure efficiency and productivity relative to the best performing contracting squadrons.

Additionally, contracting managers expressed a desire for an evaluation system which accounts for differences in squadron characteristics, mission, and purchase complexity. By allowing flexible weighting of the input and output coefficients, DEA accounts for these differences. The squadrons which received DEA ratings of 1.0 varied in size, total contracting actions, and total funds obligated.

Finally, contracting managers expressed desires for an evaluation system which combines several inputs and outputs into a single index of performance. The survey results indicated managers believe too much emphasis is currently placed on single measures of performance such as CALT. DEA demonstrated an ability to combine several individual performance measures into an aggregate rating of overall performance.

The results presented in this chapter achieved the two main research objectives. First, a DEA model was constructed for use in operational contracting performance measurement. Second, the DEA output was evaluated for its potential use to operational contracting management. DEA is a flexible methodology which allows the examination of various input and output combinations to the operational contracting process. The DEA technique proved to be an excellent addition to current methods of measuring operational contracting performance.

V. Summary, Conclusions, and Recommendations

Summary

Due to the critical mission support nature and magnitude of taxpayer dollars expended by operational contracting, the ability to measure and provide performance feedback to the contracting manager is essential. Contracting performance includes the related concepts of efficiency and productivity. Both concepts are concerned with how well a contracting squadron converts inputs or resources into outputs (42:420). Because they are major components of overall purchasing performance, the ability to measure efficiency and productivity is an important tool for operational contracting performance improvement.

The current systems to measure operational contracting efficiency and productivity contain specific weaknesses. First, the systems fail to aggregate individual performance indicators into an index of overall performance. Second, they do not measure performance relative to other operational contracting squadrons. Third, current systems do not provide feedback on specific ways to improve overall squadron productivity. Finally, they provide limited ability to compare operational contracting squadrons of different size, mission, objectives, and purchasing complexity.

Because of these limitations, SAF/AQCO and AFLMA/LGC identified a need to develop and evaluate an alternate method of measuring operational contracting performance (27). Because productivity and efficiency are major components of overall performance, this research concentrated on measuring productive efficiency of operational contracting squadrons. Specifically, the relatively new approach of Data Envelopment Analysis (DEA) was chosen to investigate as an alternate performance evaluation system.

The overall research objective was to design a DEA evaluation system that provides an alternative to current methods of measuring operational contracting performance. In order to meet this objective, a DEA model for operational contracting was developed and evaluated for potential use by contracting managers. The use of five investigative questions facilitated the research process.

<u>IQ 1 & 2: What are the Most Critical Outputs and Resources in Operational Contracting</u>? A survey of operational contracting managers revealed 16 possible operational contracting outputs and resources which were significant. After eliminating variables which provided redundant information, or variables difficult for management control, nine variables were included in the DEA model. The output variables included the number of service contracts, the number of construction contracts, the number of

commodities contracts, the total number of contracting actions, and the total dollars awarded using competitive procedures. The input variables included the total office experience level, the number of buyers, the number of clerks, and the number of managers.

IQ 3: What are the Results of the Application of the DEA Technique to Operational Contracting Performance Measurement? The DEA resulted in 15 squadrons receiving an efficiency score of 1.0. Analysis demonstrated one of these squadrons was an unenveloped solution. This squadron was not considered efficient because it could have produced the same output using less of one or more inputs. After eliminating the unenveloped solution, 14 squadrons remained efficient relative to the other squadrons in the DEA model.

Once DEA ratings were obtained, the Efficiency Reference Set (ERS) for each relatively inefficient squadron was reported. The ERS provides a list of Decision Making Units (DMUs) for the contracting manager to use in performance improvement. Specifically, the ERS for a squadron is a set of DMUs, receiving a relatively efficient DEA rating, which envelope the inefficient squadron. The ERS provides contracting managers with a set of squadrons to emulate in future operations.

IQ 4: What Information Does DEA Output Provide the Air Force Operational Contracting Manager? In addition to the efficiency score and ERS, the DEA output provided the operational contracting manager with a wealth of performance improvement information. First, the DEA output provided weights for each input and output variable used in the analysis. Each weight is analogous to marginal productivity in economic theory. For example, the weight assigned to the BUYER variable at Wurtsmith AFB was .0421. This means for every unit decrease in the number of buyers, Wurtsmith can expect a 4.2% increase in their DEA rating.

Second, DEA allowed the calculation of the excess inputs used by inefficient squadrons. This calculation was made by comparing the current input level to the inputs used by the squadrons in the ERS. Wurtsmith AFB was used for an example in Chapter IV. In order for Wurtsmith AFB to move to the efficient frontier, it could reduce its total experience level by 44.1 years, the number of buyers by 3.59, the number of clerks by 2.179, and the number of management personnel by 1.078. By making these reductions, while holding output constant, Wurtsmith AFB would become relatively efficient.

Third, DEA provides the ability to derive Hypothetical Comparison Unit (HCU) values for each inefficient DMU. Once again, Wurtsmith AFB was used as an example in Chapter IV. The HCU is a linear combination of the input and output vectors for each DMU listed in the ERS. The DEA output provides a dual variable, or shadow price, for each DMU listed in the ERS. This dual variable is the multiplier used to calculate the HCU. Once calculated, the HCU provides a target resource level for relatively inefficient DMUs. If this resource level is obtained, holding output levels constant, the DMU will receive a DEA rating of 1.0.

The final piece of performance improvement information was the single input reduction calculation. Because DEA assumes any point along the efficient frontier is obtainable, an inefficient DMU is not limited to improvements based solely on ERS and HCU analysis. An inefficient DMU can multiply each of the inputs by the DEA rating in order to reach the efficient frontier. Additionally, a simple formula can be employed to calculate the reduction required in a single input to receive a DEA rating of 1.0.

IQ 5: What Characteristics of a Performance Measurement System are Desired by Operational Contracting Managers and How Are They Addressed by DEA? The same survey used for input and output identification contained eleven questions to query contracting managers about performance measurement, evaluation, and feedback. Contracting managers indicated that improving operational contracting productivity and efficiency are important objectives. They expressed a desire for an evaluation system which can measure several inputs and outputs to the contracting process as opposed to a system which examines singular performance indicators. Finally, contracting managers indicated a desire for an evaluation system which can compare different squadrons while accounting for differences in squadron characteristics, missions, and purchase complexity.

Conclusions

The results of this research indicate DEA is an important tool for enhancing performance evaluation of Air Force operational contracting squadrons. The information provided from the DEA output appears to be an improvement over the current methods of operational contracting performance evaluation. Additionally, the DEA feedback addresses performance evaluation characteristics desired by operational contracting managers.

Strengths of DEA. There are several characteristics of DEA which demonstrate its potential for operational contracting performance evaluation. First, DEA can create a single efficiency rating based upon multiple inputs and outputs to the contracting function. Current methods of operational contracting evaluation do not allow the combination of several performance indicators into a single index of overall performance.

Because DEA allows for flexible weighting of the decision variables (inputs and outputs) it can account for differences in squadron characteristics such as size, mission, and purchase complexity. In this manner, all Air

Force operational contracting squadrons can be compared with confidence that squadron differences are taken into account. The results of the management survey indicate this characteristic is desired by operational contracting managers.

DEA provides an increased amount and quality of performance improvement information when compared with the current methods of contracting evaluation. Contracting managers indicated improvements in productivity and efficiency are important goals of performance improvement. DEA provides more than an overall rating of performance. The ability to compare squadron performance to the ERS and HCU allow managers to create a specific plan for improvement. By examining the DEA weights assigned to the inputs and outputs, the contracting manager can conduct what-if analysis concerning productivity and efficiency improvement.

Additionally, DEA gives contracting managers the ability to set specific goals for input reductions or increases in outputs. Once established, these goals can be inserted into the DEA model and a new efficiency rating established. This provides the ability to not only establish a course of action, but to inform the workforce of the resulting rating if the goals are achieved. The current methods of operational contracting performance evaluation can not tell a manager how to achieve specific goals and the overall squadron rating once the goals are achieved.

Finally, the DEA evaluation technique is well-suited for continuous process improvement. The efficient frontier established by DEA is not fixed in a permanent position. If the technique is used at given intervals, over a period of time, the frontier will continue to move towards more efficient operations. A contracting squadron originally receiving a rating of 1.0 may be surpassed by squadrons using DEA feedback to improve operations. In this manner, the entire operational contracting function can achieve continuous improvements in productivity.

<u>Limitations of the Research and DEA Technique</u>. No system of performance evaluation is without limitation. The primary limitations to the use of DEA were discussed in Chapter III of this research. However, there are four important limitations that should be reviewed at this time. These limitations apply to the data used in evaluation and the interpretation of the decision variable weights assigned by DEA.

First, this DEA application did not include any measure of quality for operational contracting squadrons. The current data available on the 7016 report provides limited quality indicators. A possible measure was the number of contracts behind schedule at each squadron. This is listed as the number of delinquent contracting actions on each 7106 report. However, this measure was omitted from the DEA model because an examination of all the squadrons under study revealed a large disparity in delinquent contracts at each base.

The lack of quality measures in this research is not an indication of a true DEA limitation. DEA is well-suited for the use of qualitative variables in the measurement of performance. However, the current BCAS system provides limited reporting of quality service indicators. Once developed, quality variables, such as the actual delivery time of a purchase, could be inserted into the current DEA model and used for a more robust indication of performance. However, since the primary purpose of this research was to measure productivity and efficiency, the lack of quality indicators did not limit the results.

Second, each DMU must collect and report input and output data in a consistent manner. The variables chosen for this research are reported consistently between operational contracting squadrons. However, future research must be careful when expanding this application to include other BCAS reported variables. For example, it was apparent that each squadron may not report the delinquent contracts measure in a consistent manner.

Third, DEA assigns input and output variables weights in accordance with a mathematical algorithm. The technique can not comprehend true economic or social value attached to a decision variable. For example, Congressional interest may increase the importance a variable such as small business dollars awarded. DEA will not automatically consider this important social aspect of a particular variable. However, the DEA linear program can be modified to limit the range of specific input or output variable weights in order to account for variables of social or economic importance.

Fourth, DEA reports only technical efficiency. Each DMU is allowed to maximize its efficiency score subject to the constraints of the linear programming problem. The contracting manager must be careful not to place economic value on a DEA generated variable weight. This limitation does not prevent the contracting manager from developing a course of action to improve performance relative to other squadrons.

Finally, DEA is only a tool to help improve operational contracting performance. The performance improvement information provided must be interpreted with management judgment. It may be difficult to reduce a specific input due to Air Force mission constraints. For example, it may not be possible for some squadrons examined in this research to reduce the number of buyers due to contingency contracting requirements.

Recommendations for Future Research

Because this research is the first attempt to apply the DEA technique to the government purchasing function, there are several areas of future research. The DEA technique is relatively new in management literature, but it appears to provide improved ability to measure performance in service providing functions. This ability makes DEA a candidate for future research endeavors.

A logical extension of this research is to increase the number of contracting squadrons evaluated. The significant input and output variables uncovered in this research could be used to extend the current DEA model to include all operational contracting squadrons in the Air Force. As long as the decision variable data is reported in a consistent manner, the analysis could also include systems acquisition organizations in AFMC.

Another possibility for future research would be to work with SAF/AQCO and AFLMA/LGC to develop quality measures to include in a future DEA application. Current AFLMA/LGC research is attempting to develop a measure of total delivery time for a purchase (27). This measure would be a true indication of how well a contracting squadron is supporting the base. As long as this measure is reported in a consistent fashion, it would be a good candidate to expand the DEA technique to include quality evaluation.

An important possibility for future research includes the integration of the DEA methodology into the everyday use at the operational contracting squadron. This would require the modification of the BCAS, or future management information system, to include the DEA methodology. Several research efforts could be conducted on this topic. First, a DEA program must be created that is user-friendly for contracting personnel. Second, the program should be integrated into the operational contracting management information system so that data from all bases is readily available for DEA modeling. Finally, system operating instructions must be created so that the DEA program could be easily understood and used.

Another possible area of future research would be to examine the effect of changing input and output variables on the overall efficiency score received by contracting squadrons. Squadrons who received a DEA rating of 1.0 in this research may not be a relatively efficient DMU if the resource and output mix is altered. Separate DEA models could be compared in order to examine the effects of changing input and output measures analyzed.

A final area of future research would include the modification of the current DEA model so that operational contracting managers could examine performance within each of their respective flights. The input and output variables could be broken down by contracting flight. This research would allow contracting managers to determine their optimal resource allocation among the flights within the squadron.

As previously stated, this research is the first application of DEA to government purchasing so there are many options for future research. Because DEA was designed for performance measurement in service-providing functions, it is well-suited for various applications in the DOD. Whenever an analysis of multiple inputs and outputs from a specific process is desired, the DEA technique can provide improved performance measurement ability.

Appendix A: 155 Input & Output Measures from 7106 Report

1. Total line items received
2. Total line items received priority 1-8
3. Percent of total line items received priority 1-8
4. Total modifications executed
5. Total dollars awarded
6. Number of sales contracts awarded
7. Dollar value of sales contracts awarded
8. Total centralized actions awarded
9. Total centralized line items awarded
10. Total centralized dollars awarded
11. Total decentralized actions awarded
12. Total decentralized dollars awarded
13. Total number of priced actions awarded
14. Total number of unpriced actions awarded
15. Percent of total line items purchased that were priced
16. Total centralized actions from 0-500
17. Total centralized actions from 501-10,000
18. Total centralized actions from 10,001-25,000
19. Total centralized actions over 25,000
20. Total decentralized actions from 0-500
21. Total decentralized actions from 501-10,000
22. Total decentralized actions from 10,001-25,000
23. Total centralized actions over 25,000
24. Total active contracting actions
25. Total active delinquent contracting actions
26. Percent total active delinquent contracts
27. Total active contract modifications
28. Percent total active contract modifications

Complex Construction

29. Total active contracts
30. Number of contracts delinquent
31. Percent of contracts delinquent
32. Number of contract modifications
33. Percent of contract modifications

Complex Service

34. Total active contracts
35. Number of contracts delinquent
36. Percent of contracts delinquent
37. Number of contract modifications
38. Percent of contract modifications

Complex Commodities

39. Total active contracts
40. Number of contracts delinquent
41. Percent of contracts delinquent
42. Number of contract modifications
43. Percent of contract modifications

Complex Architect and Engineering

44. Total active contracts
45. Number of contracts delinquent
46. Percent of contracts delinquent
47. Number of contract modifications
48. Percent of contract modifications

Less Complex Construction

49. Total active contracts
50. Number of contracts delinquent
51. Percent of contracts delinquent
52. Number of contract modifications
53. Percent of contract modifications

Less Complex Services

54. Total active contracts
55. Number of contracts delinquent
56. Percent of contracts delinquent
57. Number of contract modifications
58. Percent of contract modifications

Less Complex Commodities

59. Total active contracts
60. Number of contracts delinquent
61. Percent of contracts delinquent
62. Number of contract modifications
63. Percent of contract modifications

Basic Unpriced BPA

64. Total active contracts
65. Number of contracts delinquent
66. Percent of contracts delinquent
67. Number of contract modifications
68. Percent of contract modifications

Pre-Priced BPA Calls

69. Total active contracts
70. Number of contracts delinquent
71. Percent of contracts delinquent
72. Number of contract modifications
73. Percent of contract modifications

Automatic Purchase Orders

74. Total active contracts
75. Number of contracts delinquent
76. Percent of contracts delinquent
77. Number of contract modifications
78. Percent of contract modifications

Basic BDO

79. Total active contracts
80. Number of contracts delinquent
81. Percent of contracts delinquent
82. Number of contract modifications
83. Percent of contract modifications

Purchase Orders

84. Total active contracts
85. Number of contracts delinquent
86. Percent of contracts delinquent
87. Number of contract modifications
88. Percent of contract modifications

Unpriced Purchase Orders

89. Total active contracts
90. Number of contracts delinquent
91. Percent of contracts delinquent
92. Number of contract modifications
93. Percent of contract modifications

Delivery Orders

94. Total active contracts
95. Number of contracts delinquent
96. Percent of contracts delinquent
97. Number of contract modifications
98. Percent of contract modifications

Sales Actions

99. Total active contracts
100. Number of contracts delinquent
101. Percent of contracts delinquent
102. Number of contract modifications
103. Percent of contract modifications
104. Total competitive actions
105. Total competitive dollars
106. Total competitive and noncompetitive dollars
107. Percent competitive dollars
108. Intergovernmental actions
109. Intergovernmental dollars
110. FMS actions
111. FMS dollars
112. NAFI actions
113. NAFI dollars
114. Defense fuel actions
115. Supply center dollars
116. Zero dollar modification actions
117. Zero dollar actions
118. Non profit actions
119. Non profit dollars
120. Utilities actions
121. Utilities dollars
122. Commissary resale actions
123. Commissary resale dollars
124. Section 8A actions
125. Section 8A dollars
126. Other competitive code 98 actions
127. Other competitive code 98 dollars
128. Total set aside actions
129. Total set aside dollars
130. Total large business actions (when available for small business)

131. Total large business dollars (when available for small business)
132. Small business percentage of total dollars available for small business
133. Disadvantaged business actions
134. Disadvantaged business dollars
135. Women owned business actions
136. Women owned business dollars
137. Reserved for small business actions
138. Reserved for small business dollars
139. Authorized civilians
140. Assigned civilians
141. Authorized airmen
142. Assigned airmen
143. Authorized officers
144. Assigned officers
145. Assigned management (front office and branch chiefs)
146. Assigned purchasing/contracting specialist
147. Assigned administrative support
148. Total office experience level (years/months)
149. Average office experience level (years/months)
150. Total experience level without administrative support
151. Average experience level without administrative support
152. Priority 1-3 CALT
153. Priority 4-8 CALT
154. Priority 9-15 CALT
155. Overall CALT

Appendix B: 51 Selected Input and Output Measures

1. Last IG rating.
2. Number of contracts behind schedule (delinquent).
3. Percentage of competitive actions.
4. Number of personnel assigned versus authorized.
5. Total number of contracting actions.
6. Total number of centralized actions.
7. Total number of decentralized actions.
8. Total dollars awarded competitively.
9. Number of BPAs administered.
10. The number of administrators and buyers (excluding management and procurement clerks).
11. The number of clerical support personnel.
12. The number of management personnel (includes front office branch or flight chiefs, and Executive Officer/NCO).
13. The number of assigned civilian personnel.
14. The number of assigned officer personnel.
15. The number of assigned enlisted personnel.
16. The total office experience level.
17. The average office experience level (total experience divided by total number of personnel).
18. The total office experience level without procurement clerk or administrative support.
19. The average office experience level without procurement clerk or administrative support.
20. The total number of line items received priority 1-8.
21. The total number of line items received (all priorities).

22. The number of different customer organizations served by our office.

23. The total dollars awarded.

24. The total number of modifications executed.

25. The priority 1-3 CALT.

26. The priority 4-8 CALT.

27. The priority 9-15 CALT.

28. The average (overall) CALT.

29. The total number of Non-Appropriated Fund actions.

30. The total Non-Appropriated Fund dollars awarded.

31. The total number of Section 8A actions.

32. The total Section 8A dollars awarded.

33. The total number of line items awarded.

34. The total number of centralized line items awarded.

35. The total number of decentralized line items awarded.

36. The total centralized dollars awarded.

37. The total decentralized dollars awarded.

38. The ratio of centralized actions divided by centralized line items (measure of combining multiple line items into one action).

39. The ratio of decentralized dollars awarded by total dollars awarded (measure of decentralizing workload).

40. The ratio of decentralized line items awarded divided by total line items awarded (measure of decentralizing workload).

41. The ratio of total modifications executed divided by total centralized actions awarded.

42. The total set-aside actions awarded.

43. The total number of large business actions awarded that were available for small business (a measure of dissolving set-asides).

44. The total large business dollars awarded that were available for small business.

45. The ratio of small business dollars awarded divided by total dollars available for small business.

46. The percent competitive dollars measure (competitive dollars divided by total dollars awarded.

47. The total number of active contracts administered.

48. The total number of active A&E and construction contracts administered.

49. The total number of active service contracts administered.

50. The total number of active commodities contracts administered.

51. The ratio of priced actions awarded divided by unpriced actions.

Appendix C: Management Survey

<u>NOTE</u>: The survey questions used for this research are highlighted in bold print.

FROM: AFIT/LSA 29 March 1993

SUBJECT: Survey - Organizational Performance Factors in Operational Contracting Squadrons

TO: Survey Recipient

As part of two thesis efforts at the Air Force Institute of Technology (AFIT), we are attempting to develop improved management tools for operational contracting squadrons. To do this, the attached survey attempts to gather your opinions and judgments about factors significant to a contracting squadron's performance. Copies of the survey are being sent to squadron commanders, deputy base contracting officers, and contracting squadron first sergeants at all bases within the CONUS.

As a senior manager, you are in a unique position to provide a critical body of information necessary for these thesis efforts.
We estimate that completion of the survey will only take about twenty-five minutes. The opinions and judgment of experienced personnel such as you, will provide a significant contribution to the success of these studies.

The enclosed survey was pilot tested by a sample of contracting squadron personnel. Based upon the pilot test, the survey was revised in order to obtain all necessary data while requiring a minimum of your time.

Please mark your responses directly on the survey. No coding sheet is required. When complete, please return the completed survey in the enclosed envelope.

Due to deadlines established by AFIT, and the fact that other phases of both research projects cannot be carried out until analysis of the survey data is complete, we would appreciate if you complete and return the subject survey by **3 May 1993.**

Your cooperation in this matter is greatly appreciated. Your input will provide great insight into how operational contracting squadrons can improve their overall performance.

MARK W. FAHRENKAMP, CAPT, USAF
AFIT Graduate Student

MARK P. GARST, CAPT, USAF
AFIT Graduate Student

DOUGLAS E. JAMES, CAPT, USAF
AFIT Graduate Student

DENNIS W. GROSECLOSE, 1LT, USAF
AFIT Graduate Student

SURVEY

PART I. BACKGROUND

This section of the survey obtains information about your background. The information requested is to ensure the groups you belong to are accurately represented, not to identify you as an individual. Your anonymity will be maintained throughout this study.

1. Total months in present job position.

____

2. Which of the following applies to you?

1. Civilian
2. Officer
3. Enlisted

3. How many years of contracting experience do you have?

____

4. Wha' ıajor command are you presently assigned to?

1. Air Mobility Command
2. Air Combat Command
3. Air Training Command
4. Air Force Material Command
5. Other

5. How important is it to you that your organization achieve optimal effectiveness?

1. Of no importance.
2. Of slight importance.
3. ſoderately important.
4. Fairly important.
5. Extremely important.

6. What was the last overall command Inspector General (IG) rating of your organization?

   1. Outstanding
   2. Excellent
   3. Satisfactory
   4. Marginal
   5. Unsatisfactory
   6. Does not apply.

7. **Were you in your present job position during the last command IG inspection?**

   1. Yes
   2. No

Please indicate your opinions on the following two statements:

8. **The current command IG evaluation system satisfactorily measures organizational performance.**

   1. Strongly disagree.
   2. Disagree.
   3. Neutral.
   4. Agree.
   5. Strongly agree.

9. **An evaluation system, different from the command IG, would be useful in measuring overall organizational performance.**

   1. Strongly disagree.
   2. Disagree.
   3. Neutral.
   4. Agree.
   5. Strongly agree.

PART II. ORGANIZATIONAL PERFORMANCE FACTORS

This portion of the survey contains factors sometimes used to measure performance of operational contracting squadrons. Please indicate the importance you would assign to each factor by circling the appropriate number on the scale printed to the right of each factor. Scale values are shown below:

Scale of Importance

Definitely Not Important	Somewhat Not Important	Neutral	Somewhat Important	Definitely Important
1	2	3	4	5

PERFORMANCE FACTOR	SCALE OF IMPORTANCE
10. Number of open purchase requests.	1 2 3 4 5
11. Number of Small Business goals achieved.	1 2 3 4 5
12. Last IG rating.	1 2 3 4 5
13. Command or higher contracting awards (i.e. Best Contracting Squadron in ACC, Professionalism in Contracting, etc.)	1 2 3 4 5
14. Outstanding Unit Citation.	1 2 3 4 5
15. Number of contracts behind schedule (delinquent).	1 2 3 4 5
16. Total number of delinquent contractors.	1 2 3 4 5
17. Number of SF 129 packages mailed.	1 2 3 4 5
18. Number of new vendors identified and loaded in BCAS.	1 2 3 4 5
19. Number of Reports of Discrepancy (RODS).	1 2 3 4 5
20. Number of STEP promotions.	1 2 3 4 5
21. Number of protests received.	1 2 3 4 5

Scale of Importance

Definitely Not Important	Somewhat Not Important	Neutral	Somewhat Important	Definitely Important
1	2	3	4	5

PERFORMANCE FACTOR	SCALE OF IMPORTANCE
22. Number of protests successfully defended.	1 2 3 4 5
23. Total number of ratifications.	1 2 3 4 5
24. Percentage of competitive actions.	1 2 3 4 5
25. Number of personnel assigned versus authorized.	1 2 3 4 5
26. Total number of contracting actions.	1 2 3 4 5
27. Total number of centralized actions.	1 2 3 4 5
28. Total number of decentralized actions.	1 2 3 4 5
29. Total dollars awarded competitively.	1 2 3 4 5
30. Number of interest payments paid due to late processing of contractor invoice.	1 2 3 4 5
31. Number of contracts awarded using source selection.	1 2 3 4 5
32. Number of undefinitized actions.	1 2 3 4 5
33. Number of BPAs administered.	1 2 3 4 5
34. Number of contracting officer warrants.	1 2 3 4 5
35. Number of solicitation amendments due to contracting personnel error.	1 2 3 4 5
36. Number of customer education classes/training provided.	1 2 3 4 5

Scale of Importance

Definitely Not Important	Somewhat Not Important	Neutral	Somewhat Important	Definitely Important
1	2	3	4	5

PERFORMANCE FACTOR	SCALE OF IMPORTANCE
37. Number of man-hours expended to support deployments, contingency contracting activities, and mobility exercises.	1 2 3 4 5
38. The ratio of formal training quotas received divided by the number utilized.	1 2 3 4 5
39. The number of in-house proficiency training performed.	1 2 3 4 5
40. Number of squadron Operating Instructions.	1 2 3 4 5
41. Number of self inspections conducted.	1 2 3 4 5
42. Number of Value Engineering Change Proposals received.	1 2 3 4 5
43. Number of Value Engineering Change Proposals approved.	1 2 3 4 5
44. Percent of the time BCAS is available to users.	1 2 3 4 5
45. Number of Purchase Requests over 90 days old.	1 2 3 4 5
46. Number of Purchase Requests over 120 days old.	1 2 3 4 5
47. Number of vendor follow-ups due to late delivery.	1 2 3 4 5
48. Number of personnel qualified for at least APDP level I certification.	1 2 3 4 5
49. Number of walk-through purchase requests.	1 2 3 4 5
50. The number of administrators and buyers (excluding management and procurement clerks).	1 2 3 4 5
51. The number of clerical support personnel.	1 2 3 4 5

Scale of Importance

Definitely Not Important	Somewhat Not Important	Neutral	Somewhat Important	Definitely Important
1	2	3	4	5

PERFORMANCE FACTOR	SCALE OF IMPORTANCE
52. The number of management personnel (includes front office branch or flight chiefs, and Executive Officer/NCO).	1 2 3 4 5
53. The number of assigned civilian personnel.	1 2 3 4 5
54. The number of assigned officer personnel.	1 2 3 4 5
55. The number of assigned enlisted personnel.	1 2 3 4 5
56. The total office experience level.	1 2 3 4 5
57. The average office experience level (total experience divided by total number of personnel).	1 2 3 4 5
58. The total office experience level without procurement clerk or administrative support.	1 2 3 4 5
59. The average office experience level without procurement clerk or administrative support.	1 2 3 4 5
60. The total office operating budget (money you have to operate the office).	1 2 3 4 5
61. The total number of line items received priority 1-8.	1 2 3 4 5
62. The total number of line items received (all priorities).	1 2 3 4 5
63. The number of different customer organizations served by our office.	1 2 3 4 5
64. The total dollars awarded.	1 2 3 4 5

Scale of Importance

Definitely Not Important	Somewhat Not Important	Neutral	Somewhat Important	Definitely Important
1	2	3	4	5

PERFORMANCE FACTOR	SCALE OF IMPORTANCE
65. The total number of modifications executed.	1 2 3 4 5
66. The priority 1-3 CALT.	1 2 3 4 5
67. The priority 4-8 CALT.	1 2 3 4 5
68. The priority 9-15 CALT.	1 2 3 4 5
69. The overall (average) CALT.	1 2 3 4 5
70. The total number of Non-Appropriated Fund actions.	1 2 3 4 5
71. The total Non-Appropriated Fund dollars awarded.	1 2 3 4 5
72. The total number of Section 8A actions.	1 2 3 4 5
73. The total Section 8A dollars awarded.	1 2 3 4 5
74. The total number of line items awarded.	1 2 3 4 5
75. The total number of centralized line items awarded.	1 2 3 4 5
76. The total number of decentralized line items awarded.	1 2 3 4 5
77. The total centralized dollars awarded.	1 2 3 4 5
78. The total decentralized dollars awarded.	1 2 3 4 5
79. The ratio of centralized actions divided by centralized line items (measure of combining multiple line items into one action).	1 2 3 4 5

Scale of Importance

Definitely Not Important	Somewhat Not Important	Neutral	Somewhat Important	Definitely Important
1	2	3	4	5

PERFORMANCE FACTOR | SCALE OF IMPORTANCE

80. The ratio of decentralized dollars awarded divided by total dollars awarded (measure of decentralizing workload). 1 2 3 4 5

81. The ratio of decentralized line items awarded divided by total line items awarded (measure of decentralizing workload). 1 2 3 4 5

Note for question 82: The following ratio gives a percentage of in-house awards which required modification (a low percentage is good).

82. The ratio of total modifications executed divided by total centralized actions awarded. 1 2 3 4 5

83. The total set-aside actions awarded. 1 2 3 4 5

84. The total number of large business actions awarded that were available for small business (a measure of dissolving set-asides). 1 2 3 4 5

85. The total large business dollars awarded that were available for small business. 1 2 3 4 5

86. The ratio of small business dollars awarded divided by total dollars available for small business. 1 2 3 4 5

87. The percent competitive dollars measure (competitive dollars divided by total dollars awarded). 1 2 3 4 5

88. The total number of active contracts administered. 1 2 3 4 5

89. The total number of active A&E and construction contracts administered. 1 2 3 4 5

Scale of Importance

Definitely Not Important	Somewhat Not Important	Neutral	Somewhat Important	Definitely Important
1	2	3	4	5

PERFORMANCE FACTOR	SCALE OF IMPORTANCE
90. The total number of active service contracts administered.	1 2 3 4 5
91. The total number of active commodities contracts administered.	1 2 3 4 5

<u>Note for question 92:</u> Priced actions represent actions that were purchased from such pre-priced instruments as calls against blanket delivery orders or blanket purchase agreements and delivery orders against pre-priced contracts. Unpriced actions are those actions which required pricing action prior to award. This includes items such as purchase orders, centralized BPAs, imprest fund actions and contracts.

92. The ratio of priced actions awarded divided by unpriced actions. 1 2 3 4 5

PART III: ADDITIONAL PERFORMANCE FACTORS

Please add any additional factors you have used to evaluate contracting performance and indicate the importance of each.

93. ______________________________ 1 2 3 4 5

94. ______________________________ 1 2 3 4 5

95. ______________________________ 1 2 3 4 5

96. ______________________________ 1 2 3 4 5

97. ______________________________ 1 2 3 4 5

PART IV. OVERALL PERFORMANCE

Using the factors listed above, including the factors you may have added in questions 93-97, select the five you feel are the most important in defining organizational performance within an operational contracting squadron. Indicate your ranking of these five factors by inserting their question number in the blanks below.

________	________	________	________	________
FIRST in Importance	SECOND in Importance	THIRD in Importance	FOURTH in Importance	FIFTH in Importance

PART V. OVERALL PERFORMANCE OF YOUR SQUADRON/ORGANIZATION

Based upon the following scale, how would you rank the overall performance of the contracting squadron/organization you are assigned. This question is based solely on your belief, not the last IG rating or command evaluation. Please circle the appropriate level of performance.

Unsatisfactory Marginal Satisfactory Excellent Outstanding

PART VI. DESIRABLE CHARACTERISTICS OF A PERFORMANCE EVALUATION AND FEEDBACK SYSTEM

This part of the survey is designed to obtain managers views and desires concerning a performance evaluation and feedback system for operational contracting. In addition, this section contains questions concerning current methods of evaluating and providing feedback to the operational contracting squadron. Please indicate the importance you would assign to the statements listed below. Continue using the following scale.

Scale of Importance

Definitely Not Important	Somewhat Not Important	Neutral	Somewhat Important	Definitely Important
1	2	3	4	5

PERFORMANCE FACTOR — SCALE OF IMPORTANCE

98. ***The current IG method of performance*** **evaluation provides feedback to help improve performance which is:** 1 2 3 4 5

99. **Current command and Air Force awards provide feedback concerning performance which is:** 1 2 3 4 5

100. **Improving operational contracting squadron productivity and efficiency is a goal which is:** 1 2 3 4 5

101. **A contracting evaluation system which simultaneously evaluates several inputs and outputs to the process (as opposed to single measures such as CALT), is a tool which is:** 1 2 3 4 5

102. **A contracting evaluation system which compares all operational contracting squadrons while taking into account differences in squadron characteristics (such as manning, experience, and workload), is a tool which is:** 1 2 3 4 5

103. **A contracting evaluation system which does not rely solely upon measures which the chain of command (LG, Wing CC) find important, is a tool which is:** 1 2 3 4 5

Scale of Importance

Definitely Not Important	Somewhat Not Important	Neutral	Somewhat Important	Definitely Important
1	2	3	4	5

PERFORMANCE FACTOR | SCALE OF IMPORTANCE

104. An evaluation system which compares squadrons relative to other contracting squadrons, is a tool which is: 1 2 3 4 5

105. A contracting evaluation system which compares contracting squadrons to the best performers as opposed to the average, is a tool which is: 1 2 3 4 5

106. A contracting evaluation system which provides managers with timely feedback, including exact data on resource utilization and relative efficiencies compared with other squadrons, is a tool which is: 1 2 3 4 5

PART VII. ADDITIONAL COMMENTS ON CONTRACTING PERFORMANCE

Using the space provided below, please feel free to add any additional comments you may have concerning the performance of operational contracting squadrons.

Appendix D: HCU Derivations for Relatively Inefficient DMUs

DERIVATION OF HCU VALUES FOR CARSWELL AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For MacDill From DEA	Output & Input Vector For MacDill
SERVICE		79		78
CONST		30		118
COMOD		16		66
ACTION		47599		92658
COMP		13554752		44333345
	0.2614		0.0324	
EXP		162.98		465.5
BUYER		14		47
CLERK		1		4
MGT		6		8
Outputs & Inputs	**Dual VAR For Offut (55Cons) From DEA**	**Output & Input Vector For Offut (55Cons)**	**Dual VAR For Langley (Cen) From DEA**	**Output & Input Vector For Langley (Cen)**
SERVICE		145		71
CONST		100		0
COMOD		26		52
ACTION		47650		1875
COMP		60214506		204281786
	0.0307		0.0324	
EXP		347.39		378.23
BUYER		44		29
CLERK		6		6
MGT		8		9
Outputs & Inputs	**Dual VAR For Hanscom From DEA**	**Output & Input Vector For Hanscom**		**Composite ERS (HCU)**
SERVICE		156		43.5485
CONST		170		29.5762
COMOD		86		16.3116
ACTION		32332		19790.6864
COMP		93872860		21642028.43
	0.0873			
EXP		506.82		124.850083
BUYER		27		9.8299
CLERK		5		1.2061
MGT		7		2.9759

DERIVATION OF HCU VALUES FOR DYESS AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Minot From DEA	Output & Input Vector For Minot
SERVICE		79		66
CONST		30		86
COMOD		16		9
ACTION		47599		33962
COMP		13554752		29354337
	0.1635		0.2076	
EXP		162.98		202.38
BUYER		14		25
CLERK		1		3
MGT		6		6
Outputs & Inputs	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)	Dual VAR For Luke From DEA	Output & Input Vector For Luke
SERVICE		71		159
CONST		0		210
COMOD		52		72
ACTION		1875		25138
COMP		204281786		38278784
	0.0849		0.1154	
EXP		378.23		350.3
BUYER		29		35
CLERK		6		5
MGT		9		8
Outputs & Inputs				Composite ERS (HCU)
SERVICE				50.9946
CONST				46.9926
COMOD				17.208
ACTION				17893.0604
COMP				30071057.62
EXP				141.197665
BUYER				13.9801
CLERK				1.8727
MGT				3.9139

DERIVATION OF HCU VALUES FOR ELLSWORTH AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Luke From DEA	Output & Input Vector For Luke
SERVICE		79		159
CONST		30		210
COMOD		16		72
ACTION		47599		25138
COMP		13554752		38278784
	0.576		0.1486	
EXP		162.98		350.3
BUYER		14		35
CLERK		1		5
MGT		6		8

Outputs & Inputs	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom
SERVICE		71		156
CONST		0		170
COMOD		52		86
ACTION		1875		32332
COMP		204281786		93872860
	0.0553		0.0929	
EXP		378.23		506.82
BUYER		29		27
CLERK		6		5
MGT		9		7

Outputs & Inputs	Dual VAR For Brooks From DEA	Output & Input Vector For Brooks		Composite ERS (HCU)
SERVICE		117		98.1386
CONST		55		69.2565
COMOD		70		37.1152
ACTION		14441		35566.7716
COMP		45811728		37659297.3
	0.0905			
EXP		256.48		237.142197
BUYER		28		19.911
CLERK		1		2.2058
MGT		7		6.4263

DERIVATION OF HCU VALUES FOR GEORGE AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)
SERVICE		79		71
CONST		30		0
COMOD		16		52
ACTION		47599		1875
COMP		13554752		204281786
	0.1792		0.00308	
EXP		162.98		378.23
BUYER		14		29
CLERK		1		6
MGT		6		9

Outputs & Inputs	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom	Dual VAR For Riyad From DEA	Output & Input Vector For Riyad
SERVICE		156		8
CONST		170		9
COMOD		86		8
ACTION		32332		2644
COMP		93872860		18178744
	0.0671		0.1455	
EXP		506.82		57
BUYER		27		3
CLERK		5		3
MGT		7		4

Outputs & Inputs				Composite ERS (HCU)
SERVICE				26.00708
CONST				18.0925
COMOD				9.96196
ACTION				11089.695
COMP				12002075.62
EXP				72.6720864
BUYER				4.84632
CLERK				0.96968
MGT				2.15462

DERIVATION OF HCU VALUES FOR CANON AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Luke From DEA	Output & Input Vector For Luke
SERVICE		79		159
CONST		30		210
COMOD		16		72
ACTION		47599		25138
COMP		13554752		38278784
	0.3599		0.3671	
EXP		162.98		350.3
BUYER		14		35
CLERK		1		5
MGT		6		8
Outputs & Inputs	**Dual VAR For Langley (Cen) From DEA**	**Output & Input Vector For Langley (Cen)**	**Dual VAR For Brooks From DEA**	**Output & Input Vector For Brooks**
SERVICE		71		117
CONST		0		55
COMOD		52		70
ACTION		1875		14441
COMP		204281786		45811728
	0.000064		0.0385	
EXP		378.23		256.48
BUYER		29		28
CLERK		6		1
MGT		9		7
Outputs & Inputs				**Composite ERS (HCU)**
SERVICE				91.310044
CONST				90.0055
COMOD				34.887928
ACTION				26915.1384
COMP				20707322.41
EXP				197.1503187
BUYER				18.966956
CLERK				2.234284
MGT				5.366276

DERIVATION OF HCU VALUES FOR HOLLOMAN AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For MacDill From DEA	Output & Input Vector For MacDill
SERVICE		79		78
CONST		30		118
COMOD		16		66
ACTION		47599		92658
COMP		13554752		44333345
	0.0721		0.1858	
EXP		162.98		465.5
BUYER		14		47
CLERK		1		4
MGT		6		8

Outputs & Inputs	Dual VAR For Howard From DEA	Output & Input Vector For Howard	Dual VAR For Brooks From DEA	Output & Input Vector For Brooks
SERVICE		37		117
CONST		61		55
COMOD		42		70
ACTION		22134		14441
COMP		15971778		45811728
	0.069		0.3108	
EXP		157.68		256.48
BUYER		15		28
CLERK		3		1
MGT		7		7

Outputs & Inputs	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom		Composite ERS (HCU)
SERVICE		156		117.0277
CONST		170		108.5114
COMOD		86		70.0022
ACTION		32332		38668.1247
COMP		93872860		59409763.78
	0.3713			
EXP		506.82		377.016928
BUYER		27		29.5045
CLERK		5		3.1896
MGT		7		7.1767

DERIVATION OF HCU VALUES FOR LANGLEY (BASE) AFB

Outputs & Inputs	Dual VAR For MacDill From DEA	Output & Input Vector For MacDill	Dual VAR For Luke From DEA	Output & Input Vector For Luke
SERVICE		78		159
CONST		118		210
COMOD		66		72
ACTION		92658		25138
COMP		44333345		38278784
	0.2433		0.2422	
EXP		465.5		350.3
BUYER		47		35
CLERK		4		5
MGT		8		8

Outputs & Inputs	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom
SERVICE		71		156
CONST		0		170
COMOD		52		86
ACTION		1875		32332
COMP		204281786		93872860
	0.1482		0.0967	
EXP		378.23		506.82
BUYER		29		27
CLERK		6		5
MGT		9		7

Outputs & Inputs				Composite ERS (HCU)
SERVICE				83.0946
CONST				96.0104
COMOD				49.5188
ACTION				32036.4944
COMP				59409490.57
EXP				303.16199
BUYER				26.8208
CLERK				3.5569
MGT				5.8947

DERIVATION OF HCU VALUES FOR McCONNELL AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Luke From DEA	Output & Input Vector For Luke
SERVICE		79		159
CONST		30		210
COMOD		16		72
ACTION		47599		25138
COMP		13554752		38278784
	0.3554		0.1008	
EXP		162.98		350.3
BUYER		14		35
CLERK		1		5
MGT		6		8
Outputs & Inputs	**Dual VAR For Langley (Cen) From DEA**	**Output & Input Vector For Langley (Cen)**	**Dual VAR For Hanscom From DEA**	**Output & Input Vector For Hanscom**
SERVICE		71		156
CONST		0		170
COMOD		52		86
ACTION		1875		32332
COMP		204281786		93872860
	0.0371		0.0293	
EXP		378.23		506.82
BUYER		29		27
CLERK		6		5
MGT		9		7
Outputs & Inputs	**Dual VAR For Brooks From DEA**	**Output & Input Vector For Brooks**		**Composite ERS (HCU)**
SERVICE		117		51.73341
CONST		55		37.01065
COMOD		70		17.6471
ACTION		14441		20519.90593
COMP		45811728		19171485.92
	0.00363			
EXP		256.48		123.0465134
BUYER		28		10.47224
CLERK		1		1.23213
MGT		7		3.50321

DERIVATION OF HCU VALUES FOR OFFUT (3908th) AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)
SERVICE		79		71
CONST		30		0
COMOD		16		52
ACTION		47599		1875
COMP		13554752		204281786
	0.6531		0.2914	
EXP		162.98		378.23
BUYER		14		29
CLERK		1		6
MGT		6		9

Outputs & Inputs	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom		Composite ERS (HCU)
SERVICE		156		87.9935
CONST		170		36.712
COMOD		86		34.2626
ACTION		32332		34889.1143
COMP		93872860		77833317.97
	0.1007			
EXP		506.82		267.695234
BUYER		27		20.3129
CLERK		5		2.905
MGT		7		7.2461

DERIVATION OF HCU VALUES FOR HOMESTEAD AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Moody From DEA	Output & Input Vector For Moody
SERVICE		79		72
CONST		30		112
COMOD		16		13
ACTION		47599		19517
COMP		13554752		17416578
	0.1913		0.2665	
EXP		162.98		295.18
BUYER		14		25
CLERK		1		2
MGT		6		7
Outputs & Inputs	Dual VAR For Luke From DEA	Output & Input Vector For Luke	Dual VAR For Brooks From DEA	Output & Input Vector For Brooks
SERVICE		159		117
CONST		210		55
COMOD		72		70
ACTION		25138		14441
COMP		38278784		45811728
	0.3927		0.0535	
EXP		350.3		256.48
BUYER		35		28
CLERK		5		1
MGT		8		7
Outputs & Inputs				Composite ERS (HCU)
SERVICE				102.9995
CONST				120.9965
COMOD				38.5447
ACTION				24951.2553
COMP				24717548.02
EXP				261.128034
BUYER				24.5832
CLERK				2.7413
MGT				6.5294

DERIVATION OF HCU VALUES FOR KI SAWYER AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Moody From DEA	Output & Input Vector For Moody
SERVICE		79		72
CONST		30		112
COMOD		16		13
ACTION		47599		19517
COMP		13554752		17416578
	0.1045		0.363	
EXP		162.98		295.18
BUYER		14		25
CLERK		1		2
MGT		6		7

Outputs & Inputs	Dual VAR For Luke From DEA	Output & Input Vec :r For Luke	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom
SERVICE		159		156
CONST		210		170
COMOD		72		86
ACTION		25138		32332
COMP		38278784		93872860
	0.1528		0.036	
EXP		350.3		506.82
BUYER		35		27
CLERK		5		5
MGT		8		7

Outputs & Inputs				Composite ERS (HCU)
SERVICE				64.3027
CONST				81.999
COMOD				20.4886
ACTION				17063.8049
COMP				16967110.55
EXP				195.95311
BUYER				16.858
CLERK				1.7745
MGT				4.6424

DERIVATION OF HCU VALUES FOR GRAND FORKS AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For MacDill From DEA	Output & Input Vector For MacDill
SERVICE		79		78
CONST		30		118
COMOD		16		66
ACTION		47599		92658
COMP		13554752		44333345
	0.6941		0.00726	
EXP		162.98		465.5
BUYER		14		47
CLERK		1		4
MGT		6		8
Outputs & Inputs	Dual VAR For Minot From DEA	Output & Input Vector For Minot	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)
SERVICE		66		71
CONST		86		0
COMOD		9		52
ACTION		33962		1875
COMP		29354337		204281786
	0.5037		0.0577	
EXP		202.38		378.23
BUYER		25		29
CLERK		3		6
MGT		6		9
Outputs & Inputs				Composite ERS (HCU)
SERVICE				92.74108
CONST				64.99788
COMOD				19.11846
ACTION				50926.00988
COMP				36303052.05
EXP				240.266625
BUYER				24.32442
CLERK				2.58044
MGT				7.76418

DERIVATION OF HCU VALUES FOR LORING AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Luke From DEA	Output & Input Vector For Luke
SERVICE		79		159
CONST		30		210
COMOD		16		72
ACTION		47599		25138
COMP		13554752		38278784
	0.3154		0.0868	
EXP		162.98		350.3
BUYER		14		35
CLERK		1		5
MGT		6		8
Outputs & Inputs	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)	Dual VAR For Riyad From DEA	Output & Input Vector For Riyad
SERVICE		71		8
CONST		0		9
COMOD		52		8
ACTION		1875		2644
COMP		204281786		18178744
	0.0187		0.0351	
EXP		378.23		57
BUYER		29		3
CLERK		6		3
MGT		9		4
Outputs & Inputs				Composite ERS (HCU)
SERVICE				40.3263
CONST				28.0059
COMOD				12.5492
ACTION				17322.5699
COMP				12055910.54
EXP				90.883533
BUYER				8.1012
CLERK				0.9669
MGT				2.8955

DERIVATION OF HCU VALUES FOR POPE AFB

Outputs &	Dual VAR	Output & Input	Dual VAR	Output & Input
Inputs	For Bergstrom	Vector For	For MacDill	Vector For
	From DEA	Bergstrom	From DEA	MacDill
SERVICE		79		78
CONST		30		118
COMOD		16		66
ACTION		47599		92658
COMP		13554752		44333345
	0.0428		0.035	
EXP		162.98		465.5
BUYER		14		47
CLERK		1		4
MGT		6		8
Outputs &	Dual VAR	Output & Input	Dual VAR	Output & Input
Inputs	For Offut (55Cons)	Vector For	For Luke	Vector For
	From DEA	Offut (55Cons)	From DEA	Luke
SERVICE		245		159
CONST		100		210
COMOD		26		72
ACTION		47650		25138
COMP		60214506		38278784
	0.0442		0.1152	
EXP		347.39		350.3
BUYER		44		35
CLERK		6		5
MGT		8		8
Outputs &	Dual VAR	Output & Input	Dual VAR	Output & Input
Inputs	For Langley (Cen)	Vector For	For Hanscom	Vector For
	From DEA	Langley (Cen)	From DEA	Hanscom
SERVICE		71		156
CONST		0		170
COMOD		52		86
ACTION		1875		32332
COMP		204281786		93872860
	0.00364		0.0763	
EXP		378.23		506.82
BUYER		29		27
CLERK		6		5
MGT		9		7

DERIVATION OF HCU VALUES FOR POPE AFB (CONT.)

Outputs & Inputs				Composite ERS (HCU)
SERVICE				47.41824
CONST				46.997
COMOD				19.18948
ACTION				12756.0514
COMP				17109092.46
EXP				119.0243652
BUYER				10.38666
CLERK				1.42734
MGT				2.37886

DERIVATION OF HCU VALUES FOR NELLIS AFB

Outputs & Inputs	Dual VAR For MacDill From DEA	Output & Input Vector For MacDill	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)
SERVICE		78		71
CONST		118		0
COMOD		66		52
ACTION		92658		1875
COMP		44333345		204281786
	0.1202		0.0799	
EXP		465.5		378.23
BUYER		47		29
CLERK		4		6
MGT		8		9
Outputs & Inputs	**Dual VAR For Tyndall From DEA**	**Output & Input Vector For Tyndall**	**Dual VAR For Kelly From DEA**	**Output & Input Vector For Kelly**
SERVICE		140		111
CONST		38		98
COMOD		39		89
ACTION		45160		33277
COMP		47922318		101470275
	0.2642		0.273	
EXP		402.16		717.08
BUYER		40		60
CLERK		9		14
MGT		6		7
Outputs & Inputs	**Dual VAR For Hanscom From DEA**	**Output & Input Vector For Hanscom**		**Composite ERS (HCU)**
SERVICE		156		101.9955
CONST		170		72.3972
COMOD		86		57.5248
ACTION		32332		36377.0291
COMP		93872860		73841424.62
	0.126			
EXP		506.82		452.046509
BUYER		27		38.3165
CLERK		5		7.79
MGT		7		6.0589

DERIVATION OF HCU VALUES FOR MYRTLE BEACH AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom
SERVICE		79		156
CONST		30		170
COMOD		16		86
ACTION		47599		32332
COMP		13554752		93872860
	0.1325		0.0611	
EXP		162.98		506.82
BUYER		14		27
CLERK		1		5
MGT		6		7
Outputs & Inputs				Composite ERS (HCU)
SERVICE				19.9991
CONST				14.362
COMOD				7.3746
ACTION				8282.3527
COMP				7531636.386
EXP				52.561552
BUYER				3.5047
CLERK				0.438
MGT				1.2227

DERIVATION OF HCU VALUES FOR MOUNTAIN HOME AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Luke From DEA	Output & Input Vector For Luke
SERVICE		79		159
CONST		30		210
COMOD		16		72
ACTION		47599		25138
COMP		13554752		38278784
	0.2751		0.00139	
EXP		162.98		350.3
BUYER		14		35
CLERK		1		5
MGT		6		8
Outputs & Inputs	Dual VAR For Minot From DEA	Output & Input Vector For Minot	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)
SERVICE		66		71
CONST		86		0
COMOD		9		52
ACTION		33962		1875
COMP		29354337		204281786
	0.2151		0.0371	
EXP		202.38		378.23
BUYER		25		29
CLERK		3		6
MGT		6		9
Outputs & Inputs	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom		Composite ERS (HCU)
SERVICE		156		58.92421
CONST		170		48.9905
COMOD		86		19.46938
ACTION		32332		24678.27662
COMP		93872860		29794078.16
	0.1291			
EXP		506.82		168.317448
BUYER		27		13.83915
CLERK		5		1.79545
MGT		7		4.18992

DERIVATION OF HCU VALUES FOR EAKER AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom		Composite ERS (HCU)
SERVICE		79		20.3741
CONST		30		7.737
COMOD		16		4.1264
ACTION		47599		12275.7821
COMP		13554752		3495770.541
	0.2579			
EXP		162.98		42.032542
BUYER		14		3.6106
CLERK		1		0.2579
MGT		6		1.5474

DERIVATION OF HCU VALUES FOR BARKSDALE AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For MacDill From DEA	Output & Input Vector For MacDill
SERVICE		79		78
CONST		30		118
COMOD		16		66
ACTION		47599		92658
COMP		13554752		44333345
	0.5224		0.1233	
EXP		162.98		465.5
BUYER		14		47
CLERK		1		4
MGT		6		8
Outputs & Inputs	**Dual VAR For Langley (Cen) From DEA**	**Output & Input Vector For Langley (Cen)**	**Dual VAR For Hanscom From DEA**	**Output & Input Vector For Hanscom**
SERVICE		71		156
CONST		0		170
COMOD		52		86
ACTION		1875		32332
COMP		204281786		93872860
	0.0173		0.1105	
EXP		378.23		506.82
BUYER		29		27
CLERK		6		5
MGT		9		7
Outputs & Inputs				**Composite ERS (HCU)**
SERVICE				69.3533
CONST				49.0064
COMOD				26.8988
ACTION				39895.5725
COMP				26454329.81
EXP				205.083891
BUYER				16.5939
CLERK				1.6719
MGT				5.05

DERIVATION OF HCU VALUES FOR BEALE AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Luke From DEA	Output & Input Vector For Luke
SERVICE		79		159
CONST		30		210
COMOD		16		72
ACTION		47599		25138
COMP		13554752		38278784
	0.3872		0.1447	
EXP		162.98		350.3
BUYER		14		35
CLERK		1		5
MGT		6		8
Outputs & Inputs	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom	Dual VAR For Riyad From DEA	Output & Input Vector For Riyad
SERVICE		156		8
CONST		170		9
COMOD		86		8
ACTION		32332		2644
COMP		93872860		18178744
	0.1402		0.0332	
EXP		506.82		57
BUYER		27		3
CLERK		5		3
MGT		7		4
Outputs & Inputs				Composite ERS (HCU)
SERVICE				75.7329
CONST				66.1358
COMOD				28.9364
ACTION				26688.5286
COMP				24551849.29
EXP				186.74283
BUYER				14.3703
CLERK				1.9113
MGT				4.595

DERIVATION OF HCU VALUES FOR CASTLE AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom
SERVICE		79		156
CONST		30		170
COMOD		16		86
ACTION		47599		32332
COMP		13554752		93872860
	0.395		0.1013	
EXP		162.98		506.82
BUYER		14		27
CLERK		1		5
MGT		6		7
Outputs & Inputs				Composite ERS (HCU)
SERVICE				47.0078
CONST				29.071
COMOD				15.0318
ACTION				22076.8366
COMP				14863447.76
EXP				115.717966
BUYER				8.2651
CLERK				0.9015
MGT				3.0791

DERIVATION OF HCU VALUES FOR FAIRCHILD AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom
SERVICE		79		156
CONST		30		170
COMOD		16		86
ACTION		47599		32332
COMP		13554752		93872860
	0.5513		0.0994	
EXP		162.98		506.82
BUYER		14		27
CLERK		1		5
MGT		6		7
Outputs & Inputs	Dual VAR For MacDill From DEA	Output & Input Vector For MacDill	Dual VAR For Luke From DEA	Output & Input Vector For Luke
SERVICE		78		159
CONST		118		210
COMOD		66		72
ACTION		92658		25138
COMP		44333345		38278784
	0.0486		0.00393	
EXP		465.5		350.3
BUYER		47		35
CLERK		4		5
MGT		8		8
Outputs & Inputs	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)		Composite ERS (HCU)
SERVICE		71		63.50672
CONST		0		39.9971
COMOD		52		20.88316
ACTION		1875		34057.94439
COMP		204281786		19200660.05
	0.00045			
EXP		378.23		164.3989645
BUYER		29		12.8368
CLERK		6		1.26505
MGT		9		4.42789

DERIVATION OF HCU VALUES FOR DAVIS-MONTHAN AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For MacDill From DEA	Output & Input Vector For MacDill
SERVICE		79		78
CONST		30		118
COMOD		16		66
ACTION		47599		92658
COMP		13554752		44333345
	0.4948		0.4639	
EXP		162.98		465.5
BUYER		14		47
CLERK		1		4
MGT		6		8
Outputs & Inputs	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)		Composite ERS (HCU)
SERVICE		71		77.8862
CONST		0		69.5842
COMOD		52		40.4478
ACTION		1875		66605.0314
COMP		204281786		34790699.76
	0.0368			
EXP		378.23		310.506818
BUYER		29		29.7977
CLERK		6		2.5712
MGT		9		7.0112

DERIVATION OF HCU VALUES FOR Griffiss AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For MacDill From DEA	Output & Input Vector For MacDill
SERVICE		79		78
CONST		30		118
COMOD		16		66
ACTION		47599		92658
COMP		13554752		44333345
	0.1589		0.2378	
EXP		162.98		465.5
BUYER		14		47
CLERK		1		4
MGT		6		8
Outputs & Inputs	Dual VAR For Brooks From DEA	Output & Input Vector For Brooks	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom
SERVICE		117		156
CONST		55		170
COMOD		70		86
ACTION		14441		32332
COMP		45811728		93872860
	0.2492		0.3061	
EXP		256.48		506.82
BUYER		28		27
CLERK		1		5
MGT		7		7
Outputs & Inputs				Composite ERS (HCU)
SERVICE				108.0095
CONST				98.5704
COMOD				62.0058
ACTION				43093.0759
COMP				52847084.6
EXP				355.64584
BUYER				28.6435
CLERK				2.8898
MGT				6.7429

DERIVATION OF HCU VALUES FOR SEYMOUR - JOHNSON AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Luke From DEA	Output & Input Vector For Luke
SERVICE		79		159
CONST		30		210
COMOD		16		72
ACTION		47599		25138
COMP		13554752		38278784
	0.2032		0.1895	
EXP		162.98		350.3
BUYER		14		35
CLERK		1		5
MGT		6		8

Outputs & Inputs	Dual VAR For Minot From DEA	Output & Input Vector For Minot	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)
SERVICE		66		71
CONST		86		0
COMOD		9		52
ACTION		33962		1875
COMP		29354337		204281786
	0.2803		0.0304	
EXP		202.38		378.23
BUYER		25		29
CLERK		3		6
MGT		6		9

Outputs & Inputs				Composite ERS (HCU)
SERVICE				66.8415
CONST				69.9968
COMOD				20.9987
ACTION				24012.3164
COMP				24446342.13
EXP				167.724692
BUYER				17.3664
CLERK				2.174
MGT				4.6906

DERIVATION OF HCU VALUES FOR WHITEMAN AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For MacDill From DEA	Output & Input Vector For MacDill
SERVICE		79		78
CONST		30		118
COMOD		16		66
ACTION		47599		92658
COMP		13554752		44333345
	0.3561		0.0853	
EXP		162.98		465.5
BUYER		14		47
CLERK		1		4
MGT		6		8

Outputs & Inputs	Dual VAR For Offut (55Cons) From DEA	Output & Input Vector For Offut (55Cons)	Dual VAR For Tyndall From DEA	Output & Input Vector For Tyndall
SERVICE		245		140
CONST		100		38
COMOD		26		39
ACTION		47650		45160
COMP		60214506		47922318
	0.0169		0.0197	
EXP		347.39		402.16
BUYER		44		40
CLERK		6		9
MGT		8		6

Outputs & Inputs	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom
SERVICE		71		156
CONST		0		170
COMOD		52		86
ACTION		1875		32332
COMP		204281786		93872860
	0.0517		0.0342	
EXP		378.23		506.82
BUYER		29		27
CLERK		6		5
MGT		9		7

DERIVATION OF HCU VALUES FOR WHITEMAN AFB (CONT.)

Outputs &				Composite
Inputs				ERS (HCU)
SERVICE				50.6897
CONST				29.001
COMOD				18.1647
ACTION				27751.3602
COMP				24341996.48
EXP				148.425506
BUYER				12.9488
CLERK				1.4572
MGT				3.7771

DERIVATION OF HCU VALUES FOR NEWARK AFB

Outputs & Inputs	Dual VAR For Brooks From DEA	Output & Input Vector For Brooks	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom
SERVICE		117		156
CONST		55		170
COMOD		70		86
ACTION		14441		32332
COMP		45811728		93872860
	0.5124		0.1876	
EXP		256.48		506.82
BUYER		28		27
CLERK		1		5
MGT		7		7
Outputs & Inputs				Composite ERS (HCU)
SERVICE				89.2164
CONST				60.074
COMOD				52.0016
ACTION				13465.0516
COMP				41084477.96
EXP				226.499784
BUYER				19.4124
CLERK				1.4504
MGT				4.9

DERIVATION OF HCU VALUES FOR ROBBINS AFB

Outputs & Inputs	Dual VAR For Kelly From DEA	Output & Input Vector For Kelly	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom
SERVICE		111		156
CONST		98		170
COMOD		89		86
ACTION		33277		32332
COMP		101470275		93872860
	0.6706		0.9563	
EXP		717.08		506.82
BUYER		60		27
CLERK		14		5
MGT		7		7
Outputs & Inputs				Composite ERS (HCU)
SERVICE				223.6194
CONST				228.2898
COMOD				141.9252
ACTION				53234.6478
COMP				157816582.4
EXP				965.545814
BUYER				66.0561
CLERK				14.1699
MGT				11.3883

DERIVATION OF HCU VALUES FOR KIRTLAND AFB

Outputs & Inputs	Dual VAR For Langley (Cen) From DEA	Output & Input Vector For Langley (Cen)	Dual VAR For Hanscom From DEA	Output & Input Vector For Hanscom
SERVICE		71		156
CONST		0		170
COMOD		52		86
ACTION		1875		32332
COMP		204281786		93872860
	0.0882		0.4145	
EXP		378.23		506.82
BUYER		29		27
CLERK		6		5
MGT		9		7
Outputs & Inputs	**Dual VAR For MacDill From DEA**	**Output & Input Vector For MacDill**		**Composite ERS (HCU)**
SERVICE		78		79.8786
CONST		118		84.0114
COMOD		66		47.8102
ACTION		92658		24204.1274
COMP		44333345		62017422
	0.1148			0
EXP		465.5		296.876176
BUYER		47		19.1449
CLERK		4		3.0609
MGT		8		4.6137

DERIVATION OF HCU VALUES FOR WURTSMITH AFB

Outputs & Inputs	Dual VAR For Bergstrom From DEA	Output & Input Vector For Bergstrom	Dual VAR For Luke From DEA	Output & Input Vector For Luke
SERVICE		79		159
CONST		30		210
COMOD		16		72
ACTION		47599		25138
COMP		13554752		38278784
	0.1493		0.0864	
EXP		162.98		350.3
BUYER		14		35
CLERK		1		5
MGT		6		8
Outputs & Inputs	**Dual VAR For Hanscom From DEA**	**Output & Input Vector For Hanscom**		**Composite ERS (HCU)**
SERVICE		156		33.0047
CONST		170		30.766
COMOD		86		12.729
ACTION		32332		10827.1567
COMP		93872860		9827521.405
	0.0479			
EXP		506.82		78.875512
BUYER		27		6.4075
CLERK		5		0.8208
MGT		7		1.9223

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In an effort to improve the management feedback in operational contracting squadrons, this research concentrated on the development of an alternate method to measure operational contracting performance. Specifically, the research investigated the use of Data Envelopment Analysis (DEA) to measure the productive efficiency of 45 operational contracting squadrons. Operational contracting managers were surveyed to identify critical resources to and outputs from the contracting process. Based on this survey, four inputs and five outputs were included in the DEA model. The DEA was executed for each contracting squadron under study. The DEA output provided improved performance measurement and feedback information. DEA combined multiple inputs and outputs into a single measure of performance. Because it allows flexible weighting of decision variables, DEA accounted for differences in squadron size, mission, and purchase complexity. By examining the DEA generated Hypothetical Comparison Unit, specific input reductions and output increases were established for each relatively inefficient squadron. Finally, the DEA output addressed several desired characteristics of a performance measurement system identified by contracting managers.

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